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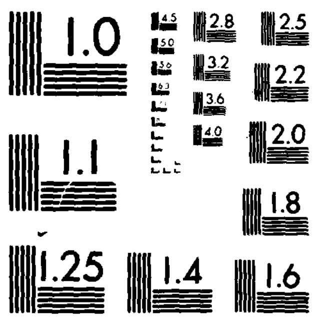

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Master's thesis

28 Aug 79

A GENERAL MODEL FOR FOOD PURCHASING IN CAPTIVE FOOD SERVICE INSTITUTIONS

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Raymond Anthony Drogan

Master of Science, August 28, 1979
(M.A., State University of New York, 1977)
(B.S., University of Florida, 1972)

114 Typed Pages

Directed by Dennis B. Webster

Many food service institutions are faced with rising food costs and low budgets. The objective of this research was to investigate potential food cost savings through optimal seasonal ordering of those food items found to exhibit seasonal price fluctuations. A general linear programming model was developed which minimizes food costs subject to space and demand constraints. The model is generally applicable to large food service institutions that have storage space available and can accurately forecast demand for menu items. The applicability of the model was demonstrated by using data from the Auburn University Food Service Department. Procedures for determining seasonal products were outlined using graphic techniques. Two models were used: one for dry storage or canned products and one for frozen storage products. The specific results obtained apply only to Auburn University; however, the results indicate, in general, that potential cost savings can be significant when large volumes of food items are

involved. Where food service institutions have the capability to store large quantities of food and price fluctuations are predictable, seasonal purchasing should be considered.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 79-186T	2. GOVT ACCESSION NO. AD-A090 763	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A General Model for Food Purchasing in Captive Food Service Institutions		5. TYPE OF REPORT & PERIOD COVERED Thesis
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Raymond Anthony Drogan		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFIT Student at: Auburn AL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS AFIT/NR WPAFB OH 45433		12. REPORT DATE 28 August 1979
		13. NUMBER OF PAGES 114
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASS
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

APPROVED FOR PUBLIC RELEASE AFR 190-17.

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23 SEP 1980

18. SUPPLEMENTARY NOTES

Approved for public release: AFR 190-17

Air Force Institute of Technology (ATC)
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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CAPTIVE FOOD SERVICE INSTITUTIONS

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A GENERAL MODEL FOR FOOD PURCHASING IN CAPTIVE FOOD SERVICE INSTITUTIONS

Raymond Anthony Drogan

A Thesis

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirements for the

Degree of

Master of Science

Auburn, Alabama

August 28, 1979

A GENERAL MODEL FOR FOOD PURCHASING IN

CAPTIVE FOOD SERVICE INSTITUTIONS

Raymond Anthony Drogan

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28 August 1979
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VITA

Raymond Anthony Drogan, son of Frank John and Leona (Zcrucko) Drogan, was born in Quonset Point, Rhode Island, on October 20, 1950. He attended Nassau County Public Schools in New York and William R. Boone High School in Orlando, Florida. After graduating from William R. Boone High School in June, 1968, he enrolled at the University of Florida in September, 1968. While at the University of Florida, he received an Air Force scholarship. He graduated in December, 1972, with honors, receiving the Bachelor of Civil Engineering Degree and was commissioned a second lieutenant in the United States Air Force. While serving in the Air Force as a radar navigator in the FB-111A, he also received a Master of Arts Degree in Liberal Studies from the State University of New York at Plattsburgh in December, 1977. He was a distinguished graduate from Squadron Officer School at Maxwell Air Force Base, Alabama, in June, 1978. He began his graduate studies in industrial engineering at Auburn in June, 1978, sponsored by the Air Force Institute of Technology. He married Linda Keim, daughter of Edwin and Dorothy (Magenheimer) Keim, in June, 1971. They have one son, Keith, and one daughter, Rachel.

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I. INTRODUCTION

Background

Many food service institutions are faced with rising food costs and low budgets. However, according to Kahrl(24), the foregoing situation particularly applies to institutional or "captive" food service operations such as colleges, correctional facilities, and military organizations. These captive institutions generally serve the same people, or people from the same general population, at every meal and are nonprofit in nature. Furthermore, large groups are normally served relatively low-cost meals in a short period of time. Because of the captive nature of the food service institutions, food requirements can be forecasted fairly accurately; therefore, storage facilities are used to obviate costly daily deliveries of food items. Kahrl notes that the captive food service establishments can not simply raise prices when food costs rise, as commercial food service operations can, because meals are usually provided for either a contract price, arranged in advance, or for "free." Therefore, new ways must be found to reduce expenses in food service operations.

Objective

The objective of this research is to investigate potential food cost savings through optimal seasonal ordering of those food items found to exhibit seasonal price fluctuations. More specifically, planning menus around seasonal food items and developing a minimal cost ordering scheme will be attempted. Warehouse space limitations and periodic demands will also be incorporated into any model developed.

Applicability

The methods employed will generally apply to any institutional or captive feeding environment with storage facilities. Such captive feeding environments are schools, colleges and universities, hospitals, prisons, or military food service operations. The differences involved between various captive feeding institutions are presumed to be negligible. The basic concepts involved are the same, only specific data such as storage space available and exact numbers of people to feed differs. All of the captive institutions serve large quantities of food to a relatively stable population in a limited time.

II. LITERATURE REVIEW

Considering the fact that many feeding institutions are faced with high food costs, the literature in the fields of inventory and cost control, menu planning, mathematical modeling, systems management, and similar topics was reviewed to find possible solutions or approaches to the problem. Accordingly, nothing appears to have been published on specifically planning menus around seasonal food items and developing a minimal cost ordering scheme. However, related areas such as food ordering, menu planning, and mathematical modeling according to nutrition and preference have been the subject of much research. Therefore, these related efforts will be summarized into two separate groups: general literature and computer applications.

General Literature

In the general area of menu planning and food ordering a great deal has been written. Visick and Van Kleeck (37) thoroughly describe the importance of menu planning in controlling food production and purchasing. They emphasize the necessity of knowing food costs and centering a food operation around the menu. Furthermore, they point out that cycle menus - menus which are repeated in sequence after the cycle completes itself, usually three to six weeks - can facilitate purchasing and storage. Cycle menu planning projects product use and allows the advantageous use of seasonal food that is in good supply.

Visick and Van Kleeck also emphasize the importance of budget requirements, storage facilities, and consumer preference. If consumer preference is known, it is possible to serve the same items more frequently.

The American Hospital Association (AHA) (4) stresses the importance of policy on, and space available for, storage of staples and frozen foods in determining purchasing decisions. The AHA generally supports the concept of ordering only quantities required for planned menus; however, it is stated that if surplus buying is utilized, make sure the items can be used to advantage and stored properly. The importance of keeping in touch with price trends is also mentioned, especially for canned products which are not readily perishable.

A general text in the area of menu planning, edited by Birchfield (10), emphasizes the importance of standard recipes in determining quantities of food required for menu items. Standard recipes list food ingredients to be used in the production of desired food items for varying quantities. However, it is also noted that standard recipes only permit accurate cost calculations after the fact because menu costs are dependent on the purchase prices of the ingredients; furthermore, the prices of ingredients vary from season to season with fluctuating product availability. In any case, the food and labor costs are considered the primary budget concerns, and standard recipes are stated as being the major way to control the food and labor costs.

Food service in general is also discussed by Kahrl (24). He states that it is currently impossible to decide on the best system for the mass feeding industry, but that this is the ultimate goal in the

food service industry. In spite of the lack of an universal system, many options such as fewer deliveries and central warehousing are possible in attempting to reduce food costs in most mass feeding operations. Furthermore, purchasing based on forecasting demand rather than some other means was listed as an improvement many food service operations can make. Colleges were considered the mass feeding institutions in the best position to reduce costs because of their large volume of business. Colleges should imitate commercial food service operations who have learned what the students prefer and serve it often. The author concludes with the comment that the best food service operations continually seek improvement and that the equipment, know-how, systems, and foods are available to do a better job.

West (38) points out that food is normally the most costly and most variable expense of a food service institution. The dietician is listed as the person responsible for menu preparation; furthermore, the importance of being aware of changing food prices is seen as a significant means of reducing costs because inexpensive items can often be increased in usage. Even though modern processing techniques permit many foods to be sold all year, stocks may be lower at certain times resulting in higher prices. Before high prices are paid for food items, the situation should be analyzed to determine what other alternatives are available. Menus should be planned well in advance, and they should be adjusted daily to the inventory of food on hand and local market conditions. Although quantity buying can save money, the author stresses the importance of purchasing the correct quantity needed for the time period considered. Other areas discussed

concerning cost control were receiving control, storeroom control, and accurate records of food costing, production, and serving. The text is a comprehensive guide to food service in institutions.

Purchasing policy is thoroughly discussed by Pedderson (29). He points out that there are so many problems plaguing food service operations that purchasing agents are often inclined to depend on suppliers to know the purchasing agent's needs; this can increase waste and costs tremendously. The importance of accurate forecasts in purchasing is thoroughly discussed. Pedderson also states that the price of food is a function of the law of supply and demand; therefore, a smart buyer can save a considerable sum of money if he is aware of the supply fluctuations.

Although the preceding references were comprehensive in nature, no specific models were discussed in any depth. However, there was general agreement on ordering only quantities of food required to meet fore-casted demand. Furthermore, food prices were recognized as fluctuating from time to time, although no specific examples were given. The price fluctuations were generally described as a function of supply and demand. A second body of literature relating to food service operations will now be discussed. Again, it only tangentially relates to the current research.

Computer Applications

Miller (27) states that economics is causing many food service directors to look at electronic data processing as a method for accounting and controlling food service operations. Some specific

computer applications discussed are recipe sizing, materials management, forecasting production, and simulation of costs for menus subject to increased food costs. Johnson (23) augments the list to include maintaining perpetual inventory, writing purchase orders, and producing status reports. Andrews (1) and (2) agrees that the computer can be extremely useful in estimating food costs, but points out that the data base must be designed before implementation can occur. An economic order quantity (EOQ) model is discussed briefly. Brown (12) also discusses inventory and cost control; she emphasizes the need for historical cost data as well as up-to-date realistic costs far enough in advance to enable selection of alternatives. Although Horton (22) acknowledges the many applications of computers, he states that not everyone should use a computer; however, he further states that all food service operations should prepare for use of a computer, in case it should become feasible at a later date. Willet (39) feels the best uses of the computer in food service are in inventory, record-keeping, ordering, warehousing, costing, and after-the-fact nutritional analysis.

Although there are many potential computer applications, Balintfy (5) discusses the general evolution of computer uses in food service. The first uses should involve data processing; this will point out the tremendous potential of computers. Secondly, experts should develop a management information system consisting of data banks, cross references, and reports. Standardized recipes are the key elements of this system. They provide information which controls many aspects of food service. The most advanced stage of computerization, as seen by Balintfy, involves menu planning by computers in order to satisfy customer preference.

This evolution of computer use will hopefully permit managers to use their time on other aspects of food service such as purchasing foods. Sager (31) also discusses the purpose of this computer evolution in food service. She feels the evolution will make cost savings possible in food ordering; it will permit the performance of services not otherwise possible; and, it will allow more effective utilization of the dietician's professional services.

Some of the more specific mathematical programming applications are discussed by Gelpi (19). Mathematical programming is a collective term used to describe a section of mathematics which includes linear, integer, nonlinear, and stochastic programming. Furthermore, mathematical programming problems of realistic size generally require the use of a high speed computer.

Smith (32) has utilized linear programming techniques to calculate minimum cost menus. His approach specifies the quantities of foods which should be consumed during a period of time in order to satisfy certain nutrient requirements. Palatability is accounted for by placing restrictions on the quantities of foods to be consumed. Baust (9) reported that some of the earlier work in the field of mathematical menu planning was also attempted by Stigler. Stigler used the simplex method of programming to minimize cost, subject to nutritional constraints; the results were limited, however, in that many menu plans were not palatable.

Building on the work of Stigler, Balintfy (6) developed an integer programming algorithm to plan minimum cost combinations of menu items such that nutrition, variety, and palatability were not violated over a sequence

of days. Balintfy's earliest work was limited to nonselective menus, menus which offer no alternative choices. Preference and desired frequency of serving of menu items were considered to be correlated closely enough to arrive at palatable menus based only on frequency. Balintfy stated that human taste defied computer logic and that dietary authorities might not like the generated menus even though the menus satisfied nutrient requirements at cheaper costs than manually planned menus. The costs utilized in the model were simply the last purchase prices.

Gue and Liggett (20) extended the work of Balintfy, in a hospital context, by formulating selective menu planning as an integer program with stochastic parameters. Their approach was based on the assumption that choices made by patients on a given diet were random in nature. Selection frequency distributions were calculated for groups of menu items, and estimates of expected values and variances of the model parameters were obtained from the respective distributions. The solution values for cost and nutrients were linear combinations of expected values. The resultant menus were suboptimal, however, in that they were planned on a multistage, or daily basis. In order to guarantee optimality, all menus must be planned simultaneously, or in a single stage. Ligget (26) reported that the multistage approach was used because many hospital patients change diets frequently, or leave the hospital; therefore, in order to insure nutritional requirements were met daily, a daily approach was used. According to Gue and Liggett (20), the estimated savings of their selective menu system at the University of Florida was approximately six cents per patient day. This is less than the amount of savings in nonselective computerized systems, but the selective menu

planning problem is more difficult to formulate precisely, because of the uncertainties caused by random variation.

Balintfy (7) discusses an alternate linear programming model where cost is a constraint and preference becomes the objective function. In other words, preference coefficients are generated for the objective function and the cost equation, formerly the objective function, is regarded as a constraint subject to some budgetary limitation. In this type of model, providing a pleasing combination of menu items is the most important objective. Also discussed was Balintfy's Computer Assisted Menu Planning (CAMP) formulation. This formulation is an optimal cost model, constrained by nutrition and serving frequency, which is available to the general public.

Nutrition appears to be the key thread in all the mathematical models discussed thus far. Since most of the research has been done in a hospital context, this is not surprising. However, Gelpi (19) reports that computer assisted menu planning systems are operational in not only hospitals, but also schools, nursing homes, and prisons thoughout the United States, Canada, Great Britain, and Western Europe. Bowman (11) reports a raw food cost saving of $7,000 a month at the Kansas City Center Hospital using Balintfy's CAMP formulation. Balintfy (6) reports savings of between 13% and 34% in food costs over traditional menu planning by hand. The savings are attributed to serving the least expensive food items subject ot the nutrition and frequency constraints. Andrews (3) notes, however, that a major limitation of the models is the necessity of accurate and up-to-date nutrient and cost data. Furthermore, Stinson (34) points out that although the use of mathematical menu planning models has resulted in cost savings, the savings alone are not

impressive. The savings may well have occurred even without the use of computer planned menus, if the dietary process were to be carefully studied.

Other models concerning menu planning have also been formulated. Gue (21) modified an earlier nonselective menu planning model to include color and texture constraints. The formulation is a zero-one type such that an item either appears on the menu (one) or does not (zero).

Because no method existed for determining changes in cost from period to period in maintaining a constant level of utility with respect to menu items, Balintfy (8) suggested using a linear programming index to determine if food prices were rising or if seasonality was accounting for changes in solution variables from period to period. In other words, an index could be developed by fixing the set of available menu items and constraints of the menu model and using the varying prices charged by the suppliers for all food items included in the model. Each period a linear programming menu solution could be obtained for each period's prices. The linear programming index is then developed by expressing the minimum cost solution for the given period relative to the minimum cost solution for some base period selected previously. If the index increases, the change can be attributed to average food prices changing. On the other hand, if the index remains fairly constant, but the menu items change in the solution, the change can be attributed to seasonal price fluctuations.

The most advanced stage in computerization of menu planning, as seen by Balintfy (5), involves satisfying customer preference or utility. According to Balintfy, past treatment of the subject was oversimplified;

preference should be described as a function of the time since the last exposure to a particular food item, as opposed to being a constant attribute. Although different individuals may have differing preference functions, for a fairly homogeneous group such as a college student body, a considerable amount of data clustering should occur. The data clustering should permit a collective utility function to represent a group's preference-frequency function. No actual model was detailed, and Balintfy noted the task would involve a tremendous amount of work.

The preceding discussion briefly summarizes the body of literature tangential to the research attempted by the current author. It has been noted that mathematical modeling and the computer have played an important role in the development of menu planning and the subsequent ordering of the necessary food items. However, the current author is more interested in the ordering of food items to reduce cost. Models currently utilized plan menus based on the most recent food prices paid, as opposed to the more significant problem of food ordering based on potentially low seasonal prices.

III. GENERAL MODEL DEVELOPMENT

General Discussion

The problem to be investigated is developing a minimum cost ordering scheme, subject to warehouse space limitations, for seasonal food items. In accomplishing this task, a general model will be developed, and then all related assumptions will be discussed. Specific applications of the general model will be reserved for a later chapter.

Once the quantity of food necessary is determined, the problem simply becomes one of determining how to order food at minimum cost so that food is available when necessary, and the available warehouse space is not exceeded.

General Model

The model is stated as follows.

$$\text{Minimize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c(i,j) * x(i,j) \qquad (1)$$

subject to

$$\sum_{i=1}^{m} b(i) * [x(i,j) + y(i,j-1)] \leq s, \quad j=1,2,\ldots,n \qquad (2)$$

and

$$x(i,j) + y(i,j-1) - y(i,j) = u(i,j) \qquad (3)$$

for $i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$

where m = number of food items

n = number of periods

$c(i,j)$ = price per unit of product i purchased in period j

$x(i,j)$ = quantity of product i purchased in period j

$b(i)$ = cubic feet per unit of product i

$y(i,j)$ = quantity of product i in storage at the end of period j

$y(i,j-1)$ = quantity of product i in storage at the end of period j-1 where $y(i,0)$ is the quantity of product i in storage at the end of the last period of the preceding cycle

s = cubic feet of storage space available

$u(i,j)$ = forecasted usage of product i in period j

Objective Function

Since the objective of the study is to minimize the cost of food items, a minimization function was chosen. Equation (1) expresses the condition that the cost of all the "m" food items ordered during a cycle (n periods) must be minimized. Therefore, a cost $c(i,j)$ for every product "i" must be determined for every "j" period. These costs will be multiplied by the quantities of food purchased $x(i,j)$ in the corresponding periods.

Constraints

Equation (2) is a space constraint. Since the warehouse space available is a major limitation, it was necessary to include the restriction in the model. Equation (2) basically states that the amount of space required by all "m" products purchased in period "j" plus the space required by the inventory left over from the previous period "j-1" must be

no greater than the available space "s." For example, if months are used as the time periods, twelve such space constraints are necessary since there are twelve months in a year. In each equation the upper limit on the space available, s, will be constant. However, because the inventory on hand may vary from period to period, the actual space available for additional purchases may differ considerably from period to period.

Since the usage of food products affects the available storage space, Equation (3) was included in the model. Equation (3) states that the quantity of product "i" purchased in the current period "j", plus the inventory of product "i" at the end of the previous period "j-1", minus the inventory on hand of product "i" at the end of the current period "j", must equal the usage of product "i" in the period "j." In other words, purchases plus beginning inventory minus ending inventory must equal usage. The usage of each product can vary from period to period; therefore, one usage equation is required for every "i" product every "j" period. This means that there will be (m * n) equations such as Equation (3). Now that the general model has been explained, a list and subsequent discussion of the underlying assumptions is in order.

Assumptions

The following key assumptions were made in developing the general model above:

1. Quantity discounts do not need to be explicitly considered in the model.
2. Additional carrying charges would not be a significant factor in any ordering scheme suggested by the results of the model.

3. Shelf-life considerations are not critical.
4. The model is "quasi-cyclical."
5. Beginning inventory for all model food items is zero.
6. Any quantity of food ordered is available at the start of the period.
7. The solution variables do not have to be restricted to integer values.
8. A reasonably stable environment exists.

Quantity discounts are not directly considered in the model. Because of the nature of captive feeding environments, large quantities of food must normally be ordered. In other words, since large quantities of food are served in short periods of time, captive food service institutions are normally forced into ordering sufficiently large quantities of food which in turn permits the realization of quantity discounts. Therefore, the model developed above will still order large quantities of food because of the demand or usage constraints. Additionally, the model will attempt to order maximum required quantities of food items at the minimum cost. Therefore, any quantity discounts that are available should be realized. However, the model will compute potential cost savings based only on seasonal prices, and it is assumed that no significant potential quantity discounts will be lost due to any new ordering scheme suggested by the model.

A second consideration in developing the model was that of carrying charges or warehousing costs. Although these costs are significant, it appears that there are no significant marginal costs involved,

because the warehouse space available in this research is assumed to be limited and fixed. According to Kahrl (24), most captive institutions can not expand existing facilities, due to a limited supply of funds, even though more warehousing space might be beneficial. Therefore, all available warehousing space must normally be fully utilized, and it is considered a major limiting factor in the model. For that reason, it is assumed that warehousing personnel requirements are the same, and the overall level of activity is constant. Consequently, any change in ordering scheme suggested by the model is mainly a change in timing, due to seasonal price fluctuations; the same quantity of food will be ordered over a period of time, such as one year, but each food item will be ordered at its minimum cost subject to the limited space available. Because storage space is limited, any possible increase in the storage of food items would be minimal, and any marginal carrying charges are assumed negligible. Furthermore, in the case of frozen foods, it is more efficient to fully utilize storage space.

Shelf-life was another aspect of the model initially considered. However, since the largest amount of food ever on hand in most food service operations is no greater than a year's supply, and Pedderson (29) indicates that this is within shelf-life tolerances, if proper temperatures are maintained in all areas of the warehouse, no shelf-life constraints were deemed necessary. The temperatures required are standard and should pose no problem. It is possible, however, to easily include shelf-life requirements. The amount of inventory for any product could be constrained to be no greater than the requirement for a specified period of time. Even though this could increase computation time and increase food cost, it is possible to model.

The model which has been developed is also assumed to be "quasi-cyclical." In other words, the model is deterministic and based on the assumption that demand is constant for the same period in different years. For example, assuming months are used as the periods, if month twelve turns out to be the optimum time to order a food item, and sufficient space is available, a year's supply of the food item will be ordered in month twelve, based on the previous year's demand for the twelve months. Additionally, the quantity stored at the end of month twelve becomes the beginning inventory for month one. This does not imply, however, that the model is completely static and only useful one time. As prices change, the model should be updated accordingly. Furthermore, if demand forecasts for individual products do change, these quantities should be adjusted in the model too.

Related to the cyclical nature of the model is the assumption that the beginning inventory of all products to be considered by the model is zero. This assumption, while not a necessity, was made for simplicity ; it enables one to determine the theoretical equilibrium ordering scheme in the first year. If in fact the initial inventory is not zero, any order quantities initially required by the model should be adjusted by subtracting the on-hand inventory from the quantity the model indicates should be ordered. Accordingly, if the initial inventory is zero, and the model does not begin ordering an item until a later month, then enough of the item must be manually ordered to meet demand until equilibrium occurs.

Another assumption is that all food ordered is available at the start of the period. This prevents an early arrival of food from overfilling the warehouse. In other words, it is a more conservative estimate of how much space is available. However, this assumption also means that if a food item is necessary during a period and it is not on hand, it will be ordered and received prior to being needed. This should pose no serious problem since food substitutions are always possible. Furthermore, where management feels the problem is significant, the previous period's requirement could be increased in the model to insure a sufficient quantity is available to meet any demand at the start of a period. In other words, a safety stock could be incorporated in the period demand forecasts to take care of lead time requirements.

The model does not restrict the solution variables to integer values. This means that, theoretically, partial units of food items may have to be ordered to guarantee optimality and feasibility. However, there are two practical solutions to the problem. First of all, it is possible to restrict solution variables to integer quantities. This will result, however, in a greater amount of time required for solution. A second possibility is to round off the fractional values of the optimal continuous solution to get an integer solution. Phillips (30) points out that this is often done in practice. However, one must be careful that the resulting solution is still feasible. If the solution is still feasible, according to Phillips, rounding causes little change as long as the values of the variables are large.

A final assumption about the general model concerns the operating environment. The model is only applicable in a fairly stable environment where patterns of prices do not change significantly. Prices can change with time, however, the relationship of prices from period to period for a given food item must not change significantly. Naturally abnormal weather conditions can account for unusual food prices and cannot be predicted. Furthermore, it should be emphasized that the model is only intended as a guide to management. The model does not make decisions, but rather suggests an ordering scheme based on the assumptions made and the available data. Specific applications of the model and related assumptions will be discussed in the following chapter.

IV. MODEL APPLICATIONS

In order to demonstrate the use of the general model, specific data were necessary. The Auburn University Food Service Department is an example of the type of captive food service institution described by the model: it is a nonprofit organization; it serves large quantities of food daily to a relatively stable population; it operates a central warehouse of limited capacity which stores food items for five cafeterias; and, it is plagued with the problem of high food costs and a low budget. Therefore, the Auburn University Food Service Department was selected for the application of the model. The food service department's personnel requirements include a director and staff, consisting of a dietician, accountant, and marketing advisor. Various other personnel are also employed to conduct daily food service operations. All necessary data were obtained from food service employees and 1977 records, unless otherwise indicated. The available data suggested the need for two models: dry goods and frozen goods. The dry goods model applies to those canned food items that require no special storage requirements. The frozen goods model, however, applies to those food items which must be kept in walk-in freezers. The resulting discussion will be broken down into the following sections:

1. Determination of Food Items to Include in Models.
2. Procedures for Determining Seasonality.
3. Consideration of Equivalent Food Substitutions.

4. Determination of Cost Coefficients.

5. Storage of Food Items.

6. Demand for Selected Food Items.

7. Resultant Dry Goods and Frozen Goods Models.

Determination of Food Items to Include in Models

The initial problem encountered was determining the food items that should be included in the models. The primary constraints were that the items must be seasonal to some extent; the items could be increased in usage without eliminating variety; and, any increased usage must be at the expense of more costly food items. By including only those items that could be increased in usage, an estimate of savings as a result of planning menus specifically around seasonal items could be obtained. Since the food service department employs a qualified dietician to plan menus, her assistance was considered essential in determining what food items should be considered.

With the assistance of the dietician, the following basic procedure was utilized. First, the cycle menus for the fall of 1977 were inspected to insure they were representative of yearly menus. Then a list of the number of times various food items were served was tabulated for lunches and dinners. Since breakfast menus were identical every day, they were not considered. The list of serving frequencies was then given to the dietician to determine what items could possibly be increased in usage. The dietician's knowledge of student preferences, obtained from surveys, and the relative prices of food items permitted her to analyze the tabulations of serving frequencies and estimate increased

usages. Furthermore, which food items could be decreased in usage were determined. At this point, a list of nine dry goods and twelve frozen goods was established. Once this information was available, it was necessary to determine if the potentially higher use food items were seasonal.

Procedures for Determining Seasonality

Determining whether or not a product is seasonal was accomplished by graphic procedures. According to Foote (18), this is an acceptable procedure and much less cumbersome than analytical procedures. Therefore, graphs of the twenty-one products selected by the dietician were constructed using wholesale price information from the Federal-State Market News Service (14), (15), and (16), U.S. Department of Agriculture (35) and (36), and National Marine Fisheries Service (28). The data for the fruits and vegetables was in an awkward format, such as price per bushel, but the data was converted to price per pound using net container weight information from the Federal-State Market News Service (17).

Wholesale price information was used primarily because the Auburn Food Service Director felt that wholesale prices were most representative of the prices paid by the foodservice department. Furthermore, monthly price periods were considered to be acceptable period lengths since they do not obscure recognition of price trends. The food service department does not order strictly retail or wholesale, but the director felt that wholesale prices would be more representative of price fluctuations which seemed to occur. However, because the food service department typically orders large quantities of food items as few times a year as possible, and sometimes as infrequently as once a year, insufficient

data was available to completely justify the use of wholesale prices. Additionally, in the case of fruits and vegetables, the only wholesale data available was for raw or fresh fruits and vegetables. It is recognized that wholesale price fluctuations for raw food items may fluctuate considerably more than the corresponding canned or processed food items; however, according to Zaccarelli (40), seasons directly affect canned and frozen food prices too. In other words, when the prices of fresh or raw food products are lowest, prices of the corresponding canned stocks should be lower. Furthermore, it should be noted that the model does not depend on using either retail or wholesale food prices, but whatever prices seem to most closely resemble the particular situation being studied.

As a result, it was assumed that raw fruit and vegetable prices can be used to determine if the corresponding processed foods are seasonal. This assumption seems reasonable, since processing costs should remain fairly constant in any given year. The processing costs have the effect of adding a constant cost to the seasonal costs of the raw food. Although the meat and fish prices used were processed prices, the prices were not always for the product in the final form desired. For example, the food service department uses boneless turkey breasts, but the available data is not for boneless turkey. Consequently, it was assumed that the meat and fish prices were representative of the actual products used. The assumption was based on the same reasoning used in the cases of raw fruit and vegetable prices: constant processing costs. Therefore, the available prices were considered acceptable indicators of seasonality.

The data on fruits and vegetables was available on a weekly basis; consequently, an arithmetic average was used to obtain monthly price estimates. Prices were available on a monthly basis, in a price per pound format, for meat and fish products.

The data for the three most recent years available (1975-1977) were plotted. Three years of data were assumed adequate, since a longer length of time would clutter the graphs, making trend recognition more difficult. The graphs were inspected to determine if the products showed any signs of seasonality. For example, the graph of apples is shown in Figure 1. Note that the plot of each year's data does not follow the same exact pattern from year to year; however, this was anticipated. Therefore, the following criterion was used to determine if a food item is seasonal: "Can a reasonably good time to order be predicted from year to year based on the graphs?" A "reasonably good time" is defined as a time period when prices are normally low from year to year relative to the other months. Referring to Figure 1, note that July represents the highest price of apples in 1975, but not for 1976 or 1977. However, the price of apples is high in July, relative to June in 1976 and 1977. Furthermore, the general curves are similar in trend of prices. Note the generally rising prices in the first half of the year and the general decline of prices in the latter portion of the year. Therefore, a reasonably good time to order apples appears to be early in the year or at the end of a year.

Of the original twenty-one products considered, under the criterion stated above, a list of twenty products was retained for study. The remaining price graphs representing the other products considered are

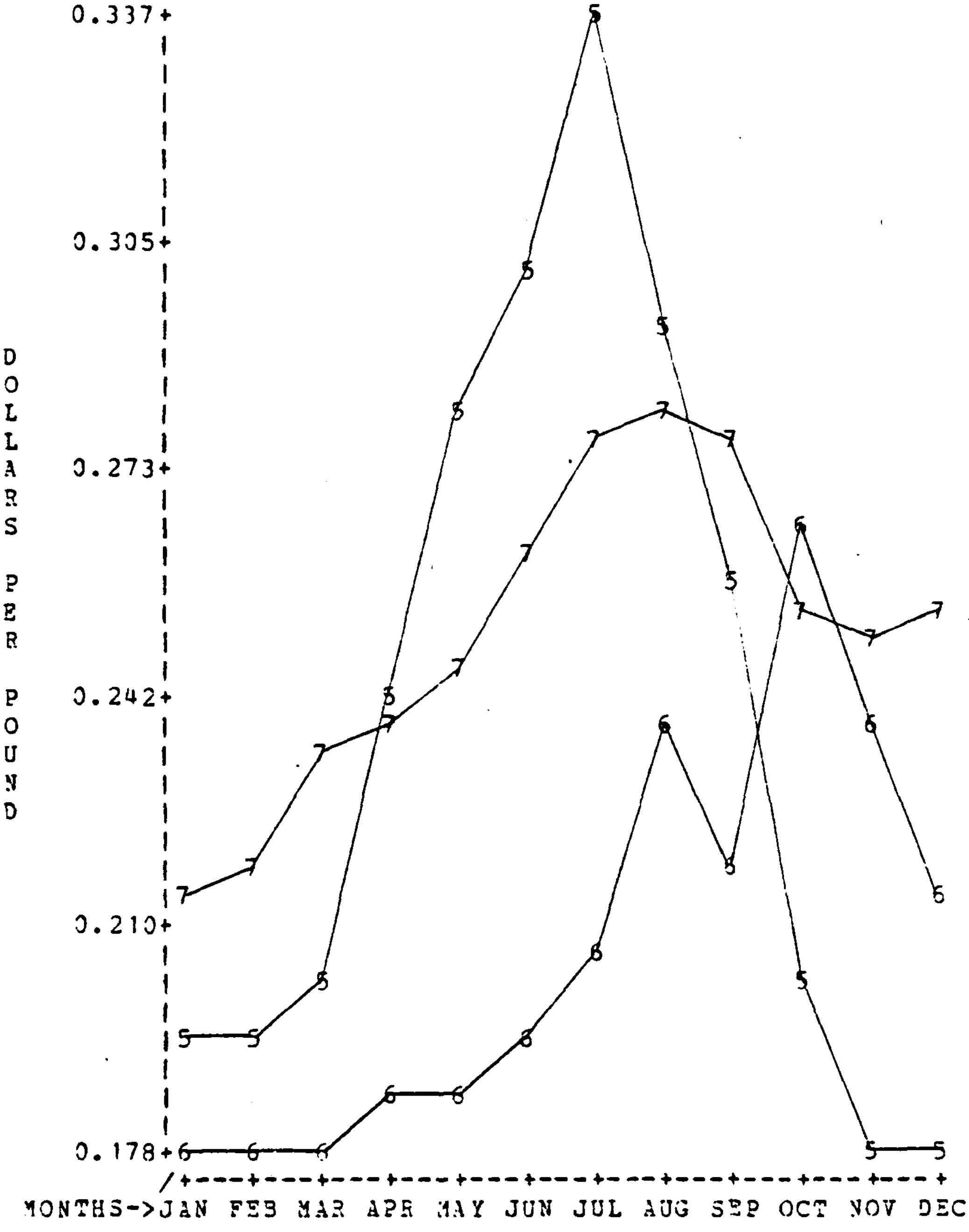

FIGURE 1. RAW APPLE PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

included in Appendix A. Nine of the products require dry storage: sliced apples, applesauce, peaches, instant potatoes, hash browns, sweet potatoes, green beans, carrots, and peas. The remaining eleven products requiring frozen storage are strawberries, mustard greens, squash, turnip greens, chicken, turkey breasts, hamburger, ham, cod fillets, perch, and pollack.

Consideration of Equivalent Food Substitutions

Since only food items that could be increased in usage were being considered, it was necessary to determine what quantity of a food item could be increased in usage as a result of the corresponding decrease in usage of some food item. If all food items were purchased in the same unit size, and each unit yielded an equivalent number of servings, there would be no problem in determining equivalent substitutions. However, this was not true in every instance; therefore, determination of what quantity of an increased item would replace a decreased usage item was based on equivalent portions. This information was determined from Birchfield (10), Pedderson (29), and the dietician employed by the food service department.

A one-case to one-case correspondence was acceptable, according to the dietician, for all canned items replacing other canned items, except for instant potatoes and hash browns. For these items equivalency was based on equivalent portions. For example, one case of hash browns serves 150 portions, but one case of lima beans only serves 138 portions; therefore, increasing hash brown 21 cases requires a reduction of (21)* (150/138) cases of lima beans, or 22.83 cases. A similar calculation

was performed for instant potatoes. In those instances where canned items replace frozen food or vice-versa, one drained pound of canned food was assumed equivalent to one net pound of frozen food in terms of serving portions. It should be noted that this assumption was acceptable to the dietician. Since the same frozen item is often received in different size packages, no attempt was made to convert increased or decreased pounds of frozen items into cases. Where frozen items replaced other frozen items, an equivalent portion was based on an equal weight basis. For example, one pound of frozen squash was considered equivalent to one pound of broccoli. Furthermore, one pound of meat was considered equivalent to one pound of another meat, except in the case of pork. All the meats considered for increased or decreased usage, except pork, were boneless. Therefore, a positive correction factor from Pedderson (29) was applied to the pounds of pork decreased to take into account the average weight of bones in pork. Summaries of the calculations and substitution amounts are included in Table 1 and Table 2 for the dry goods model and frozen goods model respectively.

Determination of Cost Coefficients

In order to minimize the effect of unusually low or high prices, a three year arithmetic average (1975-1977) of food prices was used in the model. While the average price does not necessarily reflect current costs, since costs may change each year, the relative price from month to month should still follow the general pattern of the seasonal costs plotted earlier. Furthermore, since some raw food and intermediate processed prices were used to determine cost coefficients, the averaging

TABLE 1

SUBSTITUTION EQUIVALENCES FOR DRY STORAGE FOOD ITEMS

Items Increased	Items Decreased	Cases Increased	Amount Decreased
Sliced apples	Blueberries	38	20 cases
	Cherries		18 cases
Applesauce	Cherries	15	15 cases
Peaches	Pears	100	100 cases
Instant Potatoes	Lima Beans	4	22 cases
Hash browns	Lima Beans	21	23 cases*
Sweet potatoes	Lima Beans	43	43 cases
Green beans	Frozen Brussel Sprouts	95	2131 pounds*
Carrots	Frozen Cauliflower	55	1423 pounds*
Peas	Frozen Okra	141	3807 pounds*

* Rounded to nearest integer value

TABLE 2

SUBSTITUTION EQUIVALENCES FOR FROZEN STORAGE FOOD ITEMS

Items Increased	Items Decreased	Pounds Increased	Amount Decreased
Strawberries	Canned blackberries	688.5	18 cases
Mustard greens	Broccoli	3963	3963 pounds
Squash	Broccoli	3963	3963 pounds
Turnip greens	Canned Asparagus	904	38 cases*
Chicken	Canadian Bacon	1670	1670 pounds
Turkey breast	Veal	3580	358 pounds
Hamburger	Rump roast	9648	9648 pounds
Ham	Pork	3432	4000 pounds*
Cod fillets	Flounder	5670	5670 pounds
Perch	Shrimp	5450	5450 pounds
Pollack	Shrimp	720	720 pounds

*Rounded to nearest integer value

method seemed appropriate. The one exception to this situation was peaches. Since peaches were only available from growers four months each year, the price the other eight months was considered constant at approximately seven per cent higher than the highest price paid to growers each year. This seemed reasonable since price is known to vary with supply.

Storage of Food Items

Equation (2) of the general model requires that some upper limit on the total space available for the products be determined. Therefore, the inventory records of the foodservice department were examined to determine the maximum amount of inventory space utilized at any one time for the products included in the dry goods and frozen goods models. For the dry goods model, this procedure required multiplying the cubic feet per case of each product by the maximum number of cases on hand in each month of the year. The cubic feet per case was determined for each product by measuring the dimensions of an actual case of product in inventory. This procedure resulted in an upper limit of approximately 4500 cubic feet for the month of November. For the frozen goods model, a slight modification in procedure was necessary. Since the case size often varies for a particular frozen item, the maximum number of pounds on hand in each month was determined. For example, one month a supplier may offer twenty pound cases of a product, but several months later the product may only be offered in thirty pound cases. This required the assumption that twice as many pounds of a product consumed twice as much space. Therefore, the volume in cubic feet per pound was determined for each frozen product by noting the dimensions

and net weight of an actual case of product in inventory. This procedure resulted in an upper limit of 1242 cubic feet for the products under consideration during the month of November. The basic procedure described was coordinated with the warehouse superintendent to insure nothing critical was overlooked. The amount of warehouse space to be alloted for storing a given set of products will vary, however, with the size warehouse available in a particular situation.

Demand for Selected Food Items

The food service department inventory records summarize food usage in each quarter of the year for every product. These quarterly figures had to be broken down into monthly usages in order to be useful in the model. This was accomplished according to the percentage of serving days per quarter. However, since the products considered were to be increased in usage also, a monthly correction term was necessary. The yearly increment for each product was multiplied by a monthly correction factor. The correction factor for a particular month was the number of serving days in the month divided by the number of serving days in a year. In other words, a weighted averaging technique was used.

Resultant Dry Goods and Frozen Goods Models

The nine dry products modeled, product numbers one through nine respectively, were sliced apples, applesauce, peaches, instant potatoes, hash browns, sweet potatoes, green beans, carrots, and peas. These nine products required one objective function, twelve space constraints (one for each month of the year), and 108 use constraints (one for each product every month of the year). Because of the size of the matrix

involved, 120 rows by 216 columns, a computer assisted solution was necessary; therefore, an IBM programming package as explained by Libben (25) was utilized. The data actually used for the dry goods model is included in Appendix B. It is in the form required by the computer program described by Libben. The row names used were R10,R11,...R120. R10 through R21 were the space constraints; and, R22 though R120 were the use constraints. For example, R22 through R33 were the use constraints for sliced apples, product one, and R109 through R120 were the use constraints for peas, product nine. The constraint matrix required 216 columns, named C1 through C216. The first 108 columns applied to the quantities ordered each month for every product, and the remaining 108 columns applied to the storage of each product at the end of every month. For examples, columns C1 through C12 applied to the quantities ordered of product 1, sliced apples; columns C109 through C120 applied to the storage of product 1 at the end of months one through twelve, respectively.

The frozen goods model consisted of the objective function and the space and use constraints for eleven products: strawberries, mustard greens, squash, turnip greens, chicken, turkey breasts, hamburger, ham, cod fillets, perch, and pollack. These were product numbers one through eleven, respectively. Since the constraint matrix was rather large, 144 rows by 264 columns, the computer program described by Libben (25) was utilized again. The actual data used for the frozen goods model is included in Appendix C. Similar to the dry goods model, there were twelve space constraints (one for each month of the year); and, there were 132 use constraints (one for each product every month of the year).

The row names were R12 through R155, and the column names were C1 through C264. Again, the first half of the columns applied to the ordered quantities of each food item every month, and the last half of the columns applied to the storage of the items at the end of every month.

V. RESULTS AND DISCUSSION OF RESULTS

Since one model was developed for the dry goods, and a separate model was developed for the frozen goods, the results will be discussed separately for each model.

Dry Goods Model Results

The ordering periods, order quantities, and unused alloted space for the nine dry products considered are listed in Table 3. The nine canned products, x(1) through x(9), are sliced apples, applesauce, peaches, instant potatoes, hash browns, sweet potatoes, green beans, carrots, and peas, respectively. Months one through twelve represent January through December, respectively. The resultant ordering scheme never requires more than four orders per year for any product. However, as few as one order per year resulted for three products: sliced apples, applesauce, and peaches. Therefore, the resultant ordering scheme should permit at least some potential quantity discounts to be realized in addition to the minimum seasonal food costs achieved by the model. The smallest order quantity was 23 cases for x(9), peas, in August. The break points for quantity discounts are subject to change and are, therefore, not known, but reasonable criteria for minimum ordering quantities, according to the food service department's ordering clerk are 10 or 15 cases. A review of food service records indicated that orders of 25 cases of canned products are common. Of

TABLE 3

ORDER QUANTITIES IN CASES AND CUBIC FEET OF UNUSED SPACE BY MONTH

	PRODUCT									
Month	x(1)	x(2)	x(3)	x(4)	x(5)	x(6)	x(7)	x(8)	x(9)	Unused space*
1	556	137	-	-	-	134	-	-	-	642
2	-	-	-	-	-	-	-	-	-	1360
3	-	-	-	-	-	-	-	35	-	2047
4	-	-	-	-	-	-	197	134	-	2227
5	-	-	-	-	-	-	-	-	-	2880
6	-	-	-	-	-	-	-	-	-	3553
7	-	-	643	-	-	-	3334	-	-	-
8	-	-	-	182	105	-	-	113	23	78
9	-	-	-	-	-	-	-	-	40	453
10	-	-	-	-	-	30	-	-	784	-
11	-	-	-	58	54	37	-	184	-	731
12	-	-	-	364	252	-	-	-	-	1152

*rounded to nearest integer

the 21 orders suggested by the model, only seven are for less than 100 cases; however, it is possible to modify ordering in each of those seven instances if management would like larger purchase quantities. Notice that whenever fewer than 100 cases are ordered, another order is placed within one or two months. In those instances, if management ascertains that a potential quantity discount would override seasonal price fluctuations, then the individual orders suggested by the model could be combined. The combining of orders is possible only to the extent that there is some unused space available. In the case of x(6) or sweet potatoes, ordered in the first, tenth, and eleventh months, it is not possible to combine orders due to the space restriction.

The total projected cost for the nine products ordered as a result of the model was $34,692.26. This compares with $34,691.47 for the continuous optimum solution which the computer program also yielded. The minor difference was due to a fraction of a case more of x(7) being ordered in month seven instead of month four. Since monthly usages were expressed in terms of integer cases in the model, this had the effect of making all nonoptimal purchases integer. In other words, when an order quantity resulted only to meet a monthly demand, and it was not the best time to order, only the integer quantity specified in the usage constraint was ordered. Therefore, many of the solution variables were integer even in the continuous model. This seems reasonable, since only whole cases of food items are delivered to the cafeterias, even if only a partial case is needed. The remainder is simply shelved in the cafeteria until required.

The $34,692.26 total raw food cost resulting from the model did not permit a direct measure of savings in itself, since the prices used were not the prices that the food service department would actually pay for the products in processed form. Therefore, the total raw food cost was actually an estimate of the best or minimum cost of the products before being processed. Consequently, if the maximum total cost could be determined for the same products ordered at the worst possible time, a measure of maximum potential savings could be estimated, since the processing costs should not be affected by whether or not the minimum or maximum prices were paid for the raw food items. Therefore, the resultant dollar amount could then be compared with the $34,692.26 food cost obtained earlier and the difference used as an estimate of the maximum potential saving. The procedure described above was accomplished by maximizing the model objective function with all constraints unchanged in the original model. The solution yielded a total cost of $55,190.44. The difference between the maximum and minimum solution was $20,498.12; this was considered an estimate of the maximum potential saving due to seasonal ordering.

It should be emphasized, however, that the saving listed above is an estimate of the potential saving that could be realized as a result of changing from the worst possible seasonal ordering scheme to the best possible seasonal ordering scheme. It is not known where on the continuum the Auburn University Food Service Department is currently operating, but as a result of a study by Dunn, Lawman, and Millican (13), a group of industrial engineering students at Auburn University, the food service department is attempting to order large quantities of

selected food items during what is believed to be the optimum seasons. Furthermore, food processors are probably pessimistic in anticipating their costs, so they are normally unwilling to pass on all the savings which might occur due to seasonal price fluctuations.

The $20,498.12 saving listed earlier does not give an indication of how much of the saving is attributable, at least in part, to using less expensive food items. The saving is dependent upon the increased usage of the nine model food items; therefore, the effect of using less expensive food items is not readily apparent. For this reason, a rough estimate of the effect of food substitutions was obtained separately. The lowest 1977 price that the food service department paid for each item to be increased was subtracted from the lowest price paid for the respective item to be decreased in usage. This saving per case was multiplied by the amount the product was to be increased in usage. For example, referring to Table 1, note peaches are to replace pears on a one for one basis. Food service records indicate the lowest prices paid for each were $8.80 per case and $11.47 per case, respectively. The difference of $2.67 was multiplied by the 100 cases of increased usage for a saving of $267. This procedure was used for each of the nine model products, and the total saving was $1137.64. This saving, as a result of using less expensive food items, is not nearly as significant as the potential saving from following a seasonal ordering scheme.

A final consideration was the sensitivity of the model to the available space. Therefore, the food cost determined for various space constraints, and the results are listed in Table 4. The marginal savings per cubic foot of space increased are also listed. They give some

TABLE 4

SENSITIVITY OF DRY GOODS FOOD COST TO AVAILABLE SPACE

Cubic feet of space available	Total food cost in dollars	Marginal saving in dollars per cubic foot
3000	36,233.59	--
3500	35,528.49	1.41
4000	34,974.26	0.98
4500*	34,692.26	0.69
5000	34,437.75	0.51
5500	34,327.80	0.22
6000	34,293.78	0.07
6500	34,293.78	0.00

* original solution

indication of the value of any additional storage space that might be made available, as well as an idea of the increased costs that could result from restricting available space. For instance, if 5000 cubic feet were available instead of 4500 cubic feet, the total food cost drops from \$34,692.26 to \$34,437.75. Therefore, the marginal saving is (\$34,692.26-\$34,437.75)/(500 cubic feet) or \$0.51 per cubic foot. If all the products in the model were received at once, they would require approximately 7200 cubic feet of storage space. However, since many products have different seasonal periods, 7200 cubic feet are not necessary in order to minimize seasonal food costs. In fact, any space greater than approximately 6000 cubic feet does not decrease the total seasonal food cost.

Frozen Goods Model Results

The results of the frozen goods model are listed in Table 5. The eleven products, x(1) through x(11), were strawberries, mustard greens, squash, turnip greens, chicken, turkey breasts, hamburger, ham, cod fillets, perch, and pollack, respectively. Months one through twelve represent January through December, respectively. Because the frozen storage space available is considerably less than the dry storage space, relative to the quantity of food required, more orders have to be placed. The order quantities suggested by the model are not atypical of those experienced by the food service department. Furthermore, in those instances where order quantities are indicated in succeeding months, it may be possible to combine the orders economically if the supplier is willing to withhold part of the shipment until desired. For example,

TABLE 5

ORDER QUANTITIES IN POUNDS AND CUBIC FEET OF UNUSED SPACE BY MONTH

	Product											
Month	x(1)	x(2)	x(3)	x(4)	x(5)	x(6)	x(7)	x(8)	x(9)	x(10)	x(11)	Unused space **
1	-	-	-	-	-	5779.0	7739.0	-	4773.0	13600.0	136.0	72
2	884.0	-	-	-	-	15,496.5*	7739.0	3879.5	-	-	-	-
3	1600.0	860.5*	-	1051.0	-	-	5334.0	2712.0	-	-	196.0	334
4	-	-	3105.0	1396.0	-	610.0*	26692.0	3716.0	-	-	-	-
5	6577.5	220.5*	2175.0	1443.0	-	6404.0	-	6469.5*	-	-	-	-
6	-	307.0	1250.0	904.0	-	5124.0*	-	21121.5*	735.0	-	69.0	-
7	-	774.0	2749.0	2737.0	-	3825.5*	-	-	959.0	-	100.0	-
8	-	-	-	-	-	11825.0*	-	-	835.0	-	342.0	-
9	-	133.0	3611.0	-	-	3050.0*	3541.5*	-	2148.0	-	-	-
10	-	414.0	-	1987.0	692.0	-	8107.5*	-	-	-	-	-
11	-	1254.0	8099.0	1923.0	670.0	4845.5*	8524.0	-	-	-	237.0	48
12	-	-	-	3539.0	2273.0	-	2273.0	-	-	-	-	621

*rounded to nearest half of a pound

** rounded to nearest integer

referring to Table 5 and the input data for the frozen foods in Appendix C, it can be seen that the price of product x(9) is lower in month seven than in month eight. Therefore, if the orders for month seven and eight can be combined into one order with deliveries spaced as desired, some saving in food cost could result.

The total projected cost for the eleven products ordered as a result of the frozen goods model was $165,852.27. As in the case of the dry goods, the maximum total cost for the frozen goods was determined by maximizing the model objective function. The resultant solution was $179,777.22 indicating a maximum potential saving of $13,924.95. It seems reasonable that the potential frozen goods saving would be less than the potential dry goods saving, since the storage space is more severely restricted for the frozen goods.

As in the dry goods model, the $13,924.95 saving does not give an indication of how much of the saving is attributable, at least in part, to using less expensive food items as substitutes for more costly food items. Therefore, the same procedure that was utilized in the dry goods analysis to estimate the effect of food substitutions was applied to the frozen goods. The increased usage of the eleven products resulted in a total saving of $16,148.30. This saving, when compared to the total estimated frozen food cost for the products considered, appears significant.

Again, a final consideration was the sensitivity of the model to the available space. Therefore, the sensitivity analysis summarized in Table 6 was conducted. The marginal saving decreases as more space is made available up until approximately 5300 cubic feet of space. Any space beyond that does not decrease total food cost at all. If all

TABLE 6

SENSITIVITY OF FROZEN GOODS FOOD COST TO AVAILABLE SPACE

Cubic Feet of Space Available	Total Food Cost in Dollars	Marginal Saving in Dollars per Cubic Foot
1000	167,080.27	-
1100	166,463.24	6.17
1200	166,012.52	4.51
1242*	165,852.27	3.82
1400	165,301.09	3.49
1521	164,907.65	3.25
1800	164,197.44	2.55
2000	163,855.42	1.71
3000	162,447.42	1.41
4000	161,725.92	0.72
5000	161,590.34	0.14
5250	161,585.80	0.02
5500	161,585.80	0.00

*original solution

the products in the model were ordered at once, 6046 cubic feet of space would be required. 1521 cubic feet were specifically chosen as one space constraint in Table 6. If one incorporates 50% of the space made available by decreasing usage and subsequent storage of frozen food items, an additional 279 cubic feet are available for storage. Therefore, the original 1242 cubic feet plus the additional 279 cubic feet result in 1521 cubic feet. The model definitely appears sensitive to the space available, and savings as a result of seasonal ordering appear to be directly affected by the space available.

VI. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Although some of the assumptions of the current research may violate reality to a certain degree, when the inaccuracy of the available data is considered, the general model appears to be a useful tool in determining an optimal ordering scheme. It appears that significant food cost savings can be realized by attempting to order selected food items during their optimal seasons. Although the optimal ordering time may vary somewhat from year to year and location to location, price trends seem to exist which permit isolation of certain months as generally good ordering periods. Furthermore, it appears that unfavorable times to order can also be isolated for many products. Although only twenty products were studied in depth, it is possible that many other products also exhibit seasonal price fluctuations. However, the savings which seasonal ordering could generate are dependent upon available storage space and fairly accurate demand forecasts. If food is ordered which can not be consumed within shelf-life tolerances, no ultimate savings are realized. Nevertheless, many food items are used in fairly constant quantities from year to year, and accurate usage forecasts are possible. Although the general model of seasonal ordering has general applicability for many food service institutions, the specific results of this study are only applicable to the Auburn University Food Service Department.

It does not appear that the Auburn University Food Service Department can increase its usage of seasonal items very much. Therefore, any significant savings would largely be the result of seasonal ordering for those quantities of food items which it already uses. However, where seasonal food substitutions are possible and will not be met by customer resistance, the substitutions can result in some food cost savings. The potential savings appear greatest for meat and fish substitutions.

Although suppliers may offer quantity discounts, it is the author's opinion that the discounts result largely from the seasonal price fluctuations to the supplier. Large order quantities do reduce expenses for the supplier, and large volume can justify reducing prices somewhat, but the large discounts often received indicate that some other factor may be involved. In other words, quantity discounts really seem to be the result of anticipated low seasonal costs, at least to some extent. Therefore, those food service institutions that only order sufficient quantities to meet weekly or monthly demands may not be able to realize the full benefits of seasonal price fluctuations. Prices will still be less expensive at certain times of the year, but not as much as they should be for the supplier to realize a constant percentage profit. It was implied in the previous chapter that a supplier's desire for profit is not the only factor involved in pricing food items to his customers. The supplier sets his prices based on anticipated supply or costs, and supply forecasts are normally made on the conservative side. Furthermore, seasonal ordering is not a readily accepted concept by food service institutions. If

suppliers knew that customers were trying to order only at optimal periods, large quantity discounts might not be offered as frequently.

Recommendations

As is the case in most research, some related areas were uncovered which can be further investigated. Therefore, some recommendations will be made as to which of these areas warrant further research.

A major problem was the availability of data. Data for products in intermediate form were utilized for reasons which were discussed earlier. However, in hindsight, prices which the Auburn University Food Service Department paid during 1977 for the products considered in the model were compared with the model prices to see if the price trends were similar. The prices actually paid for the dry goods and frozen goods model products are listed in Table 7 and Table 8, respectively. Only those products which were ordered more than once in the year are listed. In comparing Figure 1 and the other figures included in Appendix A with the limited data available in Table 7 and Table 8, it was noted that the price trends were not as similar in shape to the seasonality graphs as anticipated. However, in general, the similarity of trends seems stronger for the frozen goods than for the dry goods. Moreover, the similarity seems greatest for the meat items considered. For example, comparing the data for ham in Figure 15 with the data in Table 8, one can see the prices are generally low in April and high at the end of the year. Moreover, it should be emphasized that it is not known what, if any, quantity discounts are confounded within the prices indicated in Table 7 and Table 8. If quantity discounts were received on some orders, but not for all orders, the comparison of prices actually

TABLE 7

PRICES PER CASE* PAID BY THE AUBURN UNIVERSITY FOOD SERVICE DEPARTMENT

FOR DRY GOODS MODEL FOOD ITEMS IN 1977

	MONTHS											
PRODUCT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sliced Apples	--	14.04 55	11.95 300	--	--	--	--	--	--	--	13.07 500	--
Applesauce	--	--	--	--	--	10.20 50	--	10.20 35	--	--	9.79 100	--
Hash Browns	--	11.09 70	--	11.19 90	--	--	11.19 110	--	--	12.95 80	--	--
Sweet Potatoes	--	--	--	--	--	11.80 25	--	--	--	10.35 10	14.72 100	--
Green Beans	--	--	7.68 1000	--	--	7.89 400	--	--	--	8.12 60	8.29 1555	--
Carrots	7.40 40	7.60 30	7.68 75	--	--	8.08 50	--	--	--	8.00 30	7.88 20	--
Peas	--	--	--	--	--	9.72 199	--	--	--	8.48 500	--	--

* cases ordered per month are listed beneath prices

-- no purchases made in month

TABLE 8

PRICES PER POUND* PAID BY THE AUBURN UNIVERSITY FOOD SERVICE DEPARTMENT

FOR FROZEN GOODS MODEL FOOD ITEMS IN 1977

	MONTHS											
PRODUCT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Strawberries	0.530 2250	--	--	0.470 2925	--	0.440 2250	--	--	--	0.440 2250	--	--
Squash	0.310 2850	--	--	0.320 3600	--	0.280 2700	--	--	0.300 4500	0.330 4644	--	--
Trunip Greens	0.257 4500	--	--	0.275 1800	--	0.285 2700	--	--	--	0.282 5400	0.254 1800	--
Chicken	--	--	1.730 250	--	1.52 2000	--	--	--	--	--	1.62 1000	--
Trukey Breast	--	0.910 7029	--	0.920 1028	0.970 14,731	--	--	--	--	--	1.00 16,784	--
Hamburger	0.680 15,060	0.680 4980	0.690 7656	--	.690 7618	--	0.660 12,000	--	--	0.709 3220	0.709 5460	0.709 2940
Ham	1.67 3705	--	--	1.55 3420	--	--	1.60 2850	--	1.62 1425	1.72 5358	--	1.80 2850
Perch	1.02 2100	--	1.01 2500	--	--	1.01 1250	1.05 1250	--	--	--	1.04 1250	--

* pounds ordered per month are listed beneath prices

-- no purchases made in month

paid with model prices is not as meaningful. As a result, if price quotes could have been obtained from food supplie on a monthly basis over a period of two or three years, more realistic cost coefficients could have been generated in the model. Perhaps that would have obviated the need for maximizing the model objective function, and a more direct estimate of potential food cost savings would have been possible because actual purchase prices would have been more accurately represented.

This research definitely lends itself to further development. Many other food products are thought to be seasonal. Although the dietician only felt that twenty food products could be increased in usage, many of the other food products utilized could still be ordered on a seasonal basis once appropriate cost coefficients were developed. Although increasing the number of products to model increases the size of the problem, the potential savings would appear to justify the effort. Furthermore, in any particular application of the general model, the optimum size warehouse for all required products is a related problem not fully considered in the current research. The analysis could incorporate the time value of money considerations as they relate to alternate short term investments. In other words, could short term investments prove more beneficial than ordering large quantities of foods before necessary in order to achieve seasonal savings? Therefore, this research should be regarded as a possible new direction in food ordering for captive food service operations.

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APPENDICES

A. Price Graphs of Model Food Items

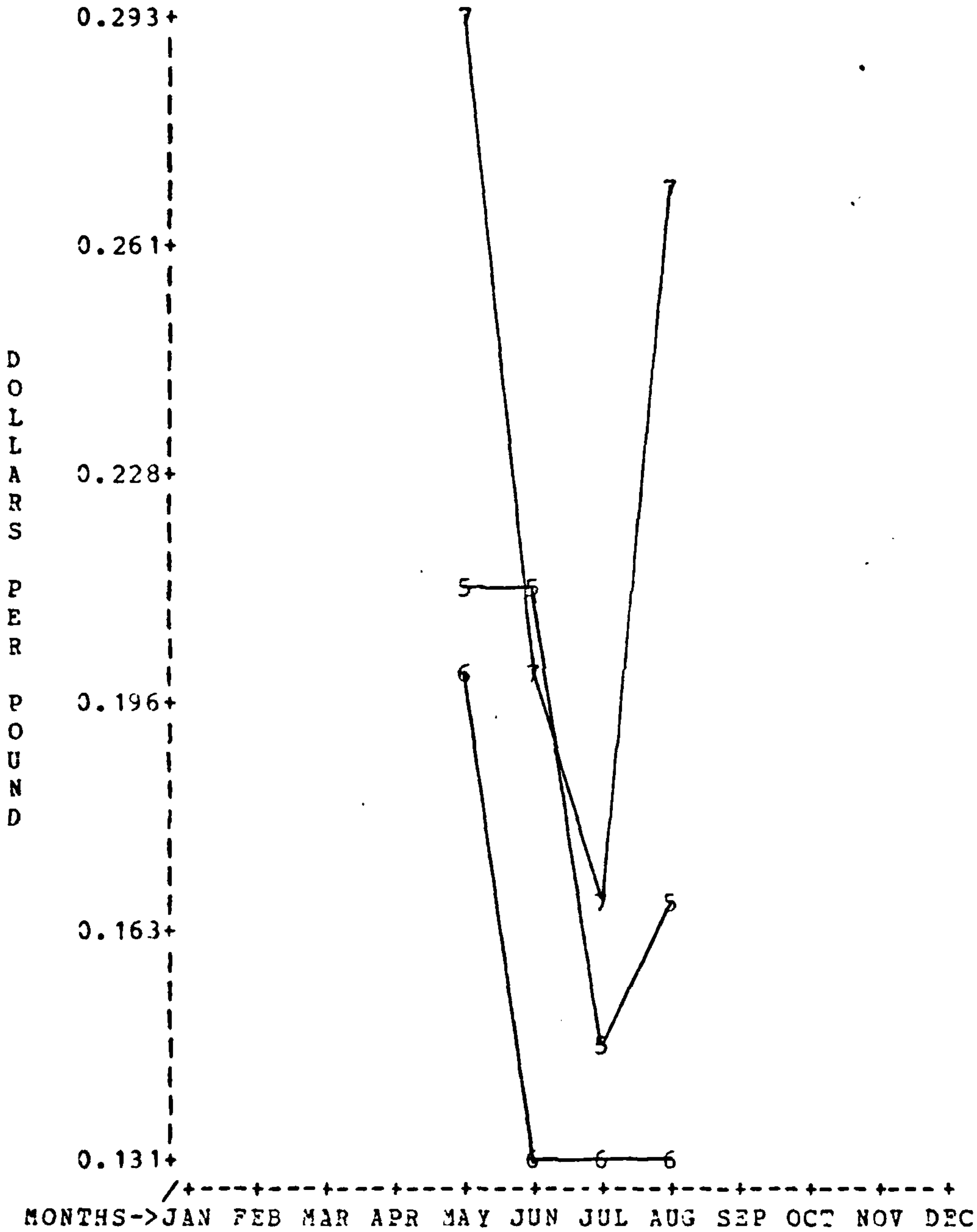

FIGURE 2. RAW PEACH PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

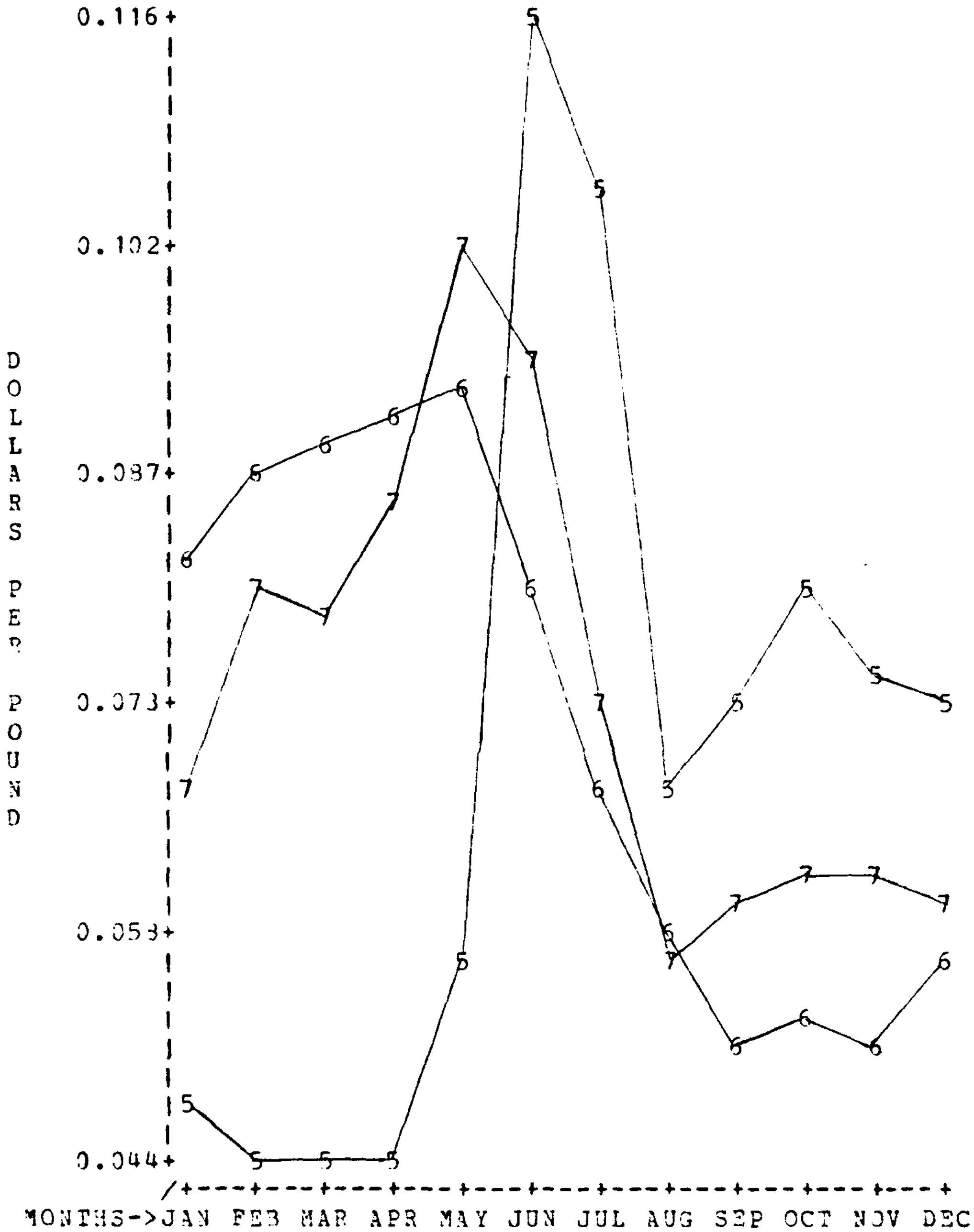

FIGURE 3. RAW POTATOE PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

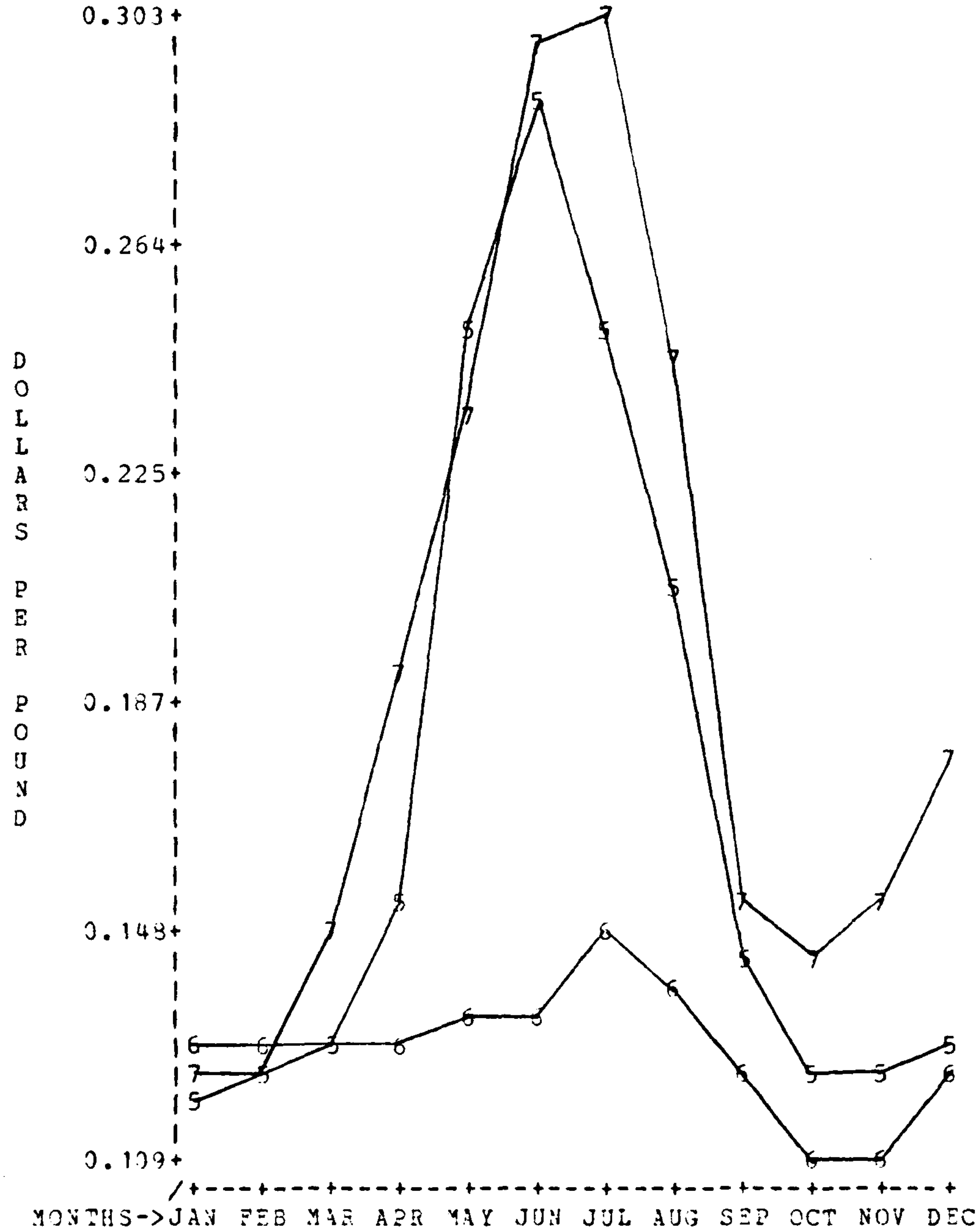

FIGURE 4. RAW SWEET POTATOE PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

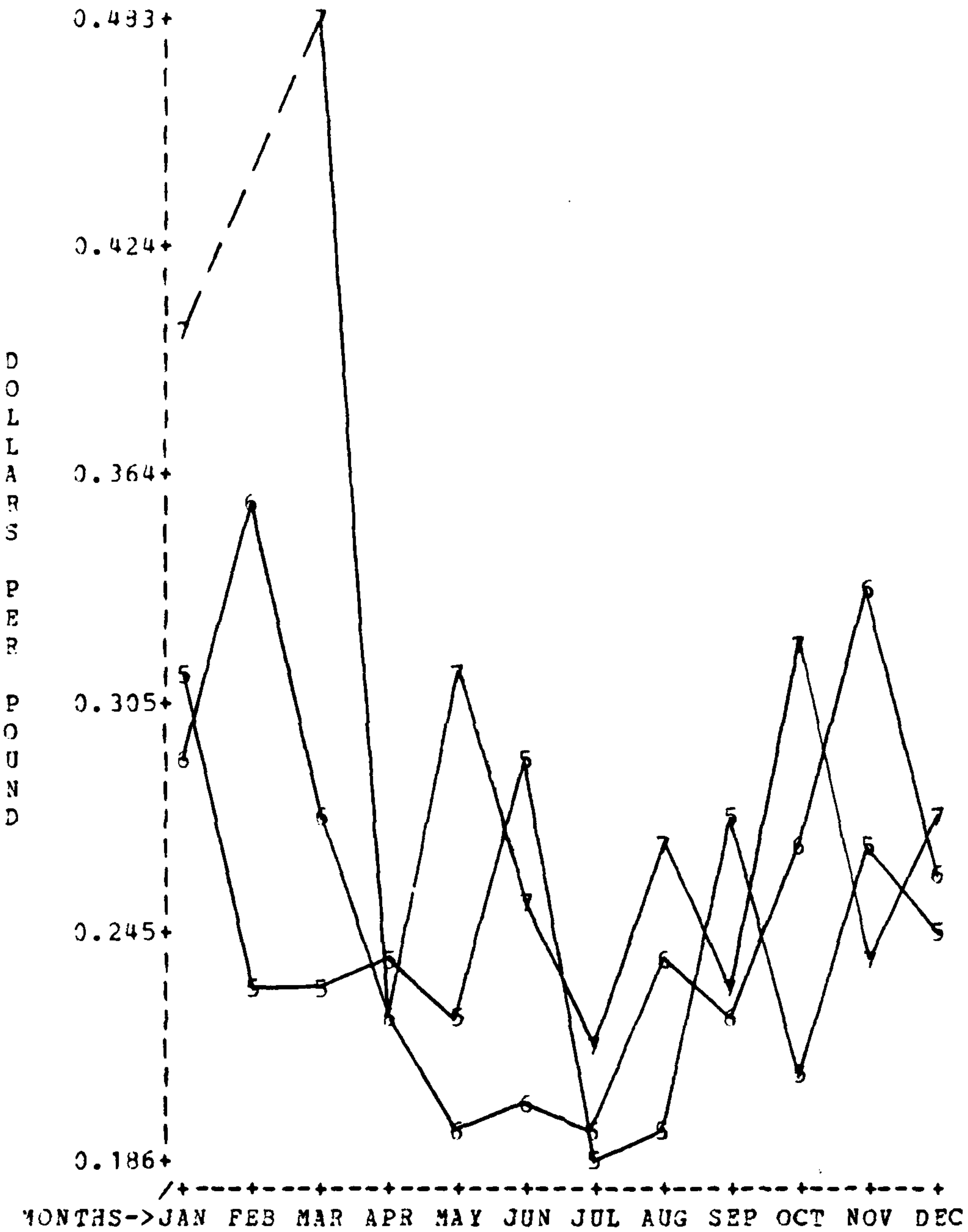

FIGURE 5. RAW GREEN BEAN PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

Dotted line indicates no price data available

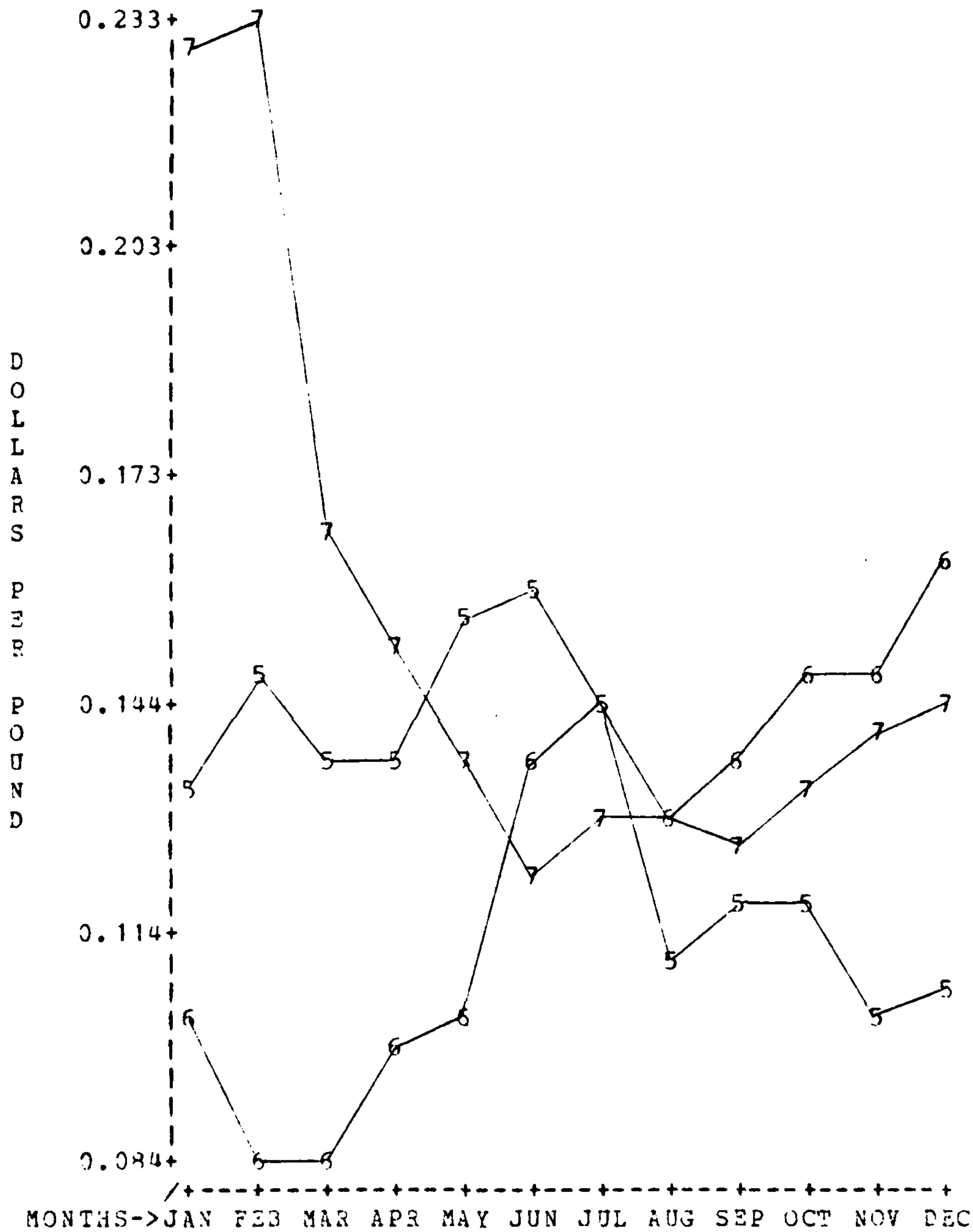

FIGURE 6. RAW CARROT PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

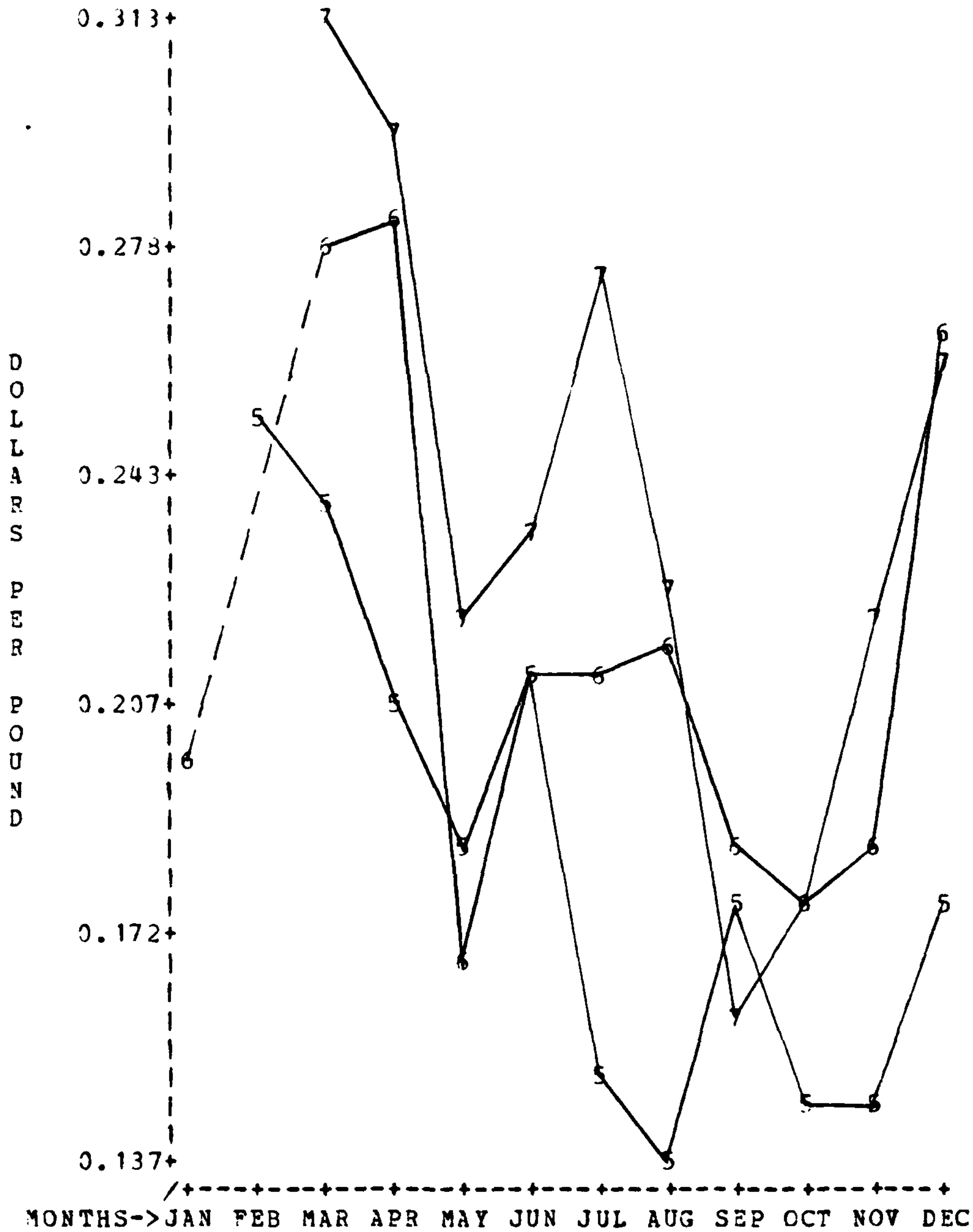

FIGURE 7. RAW PEA PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

Dotted line indicates no price data available

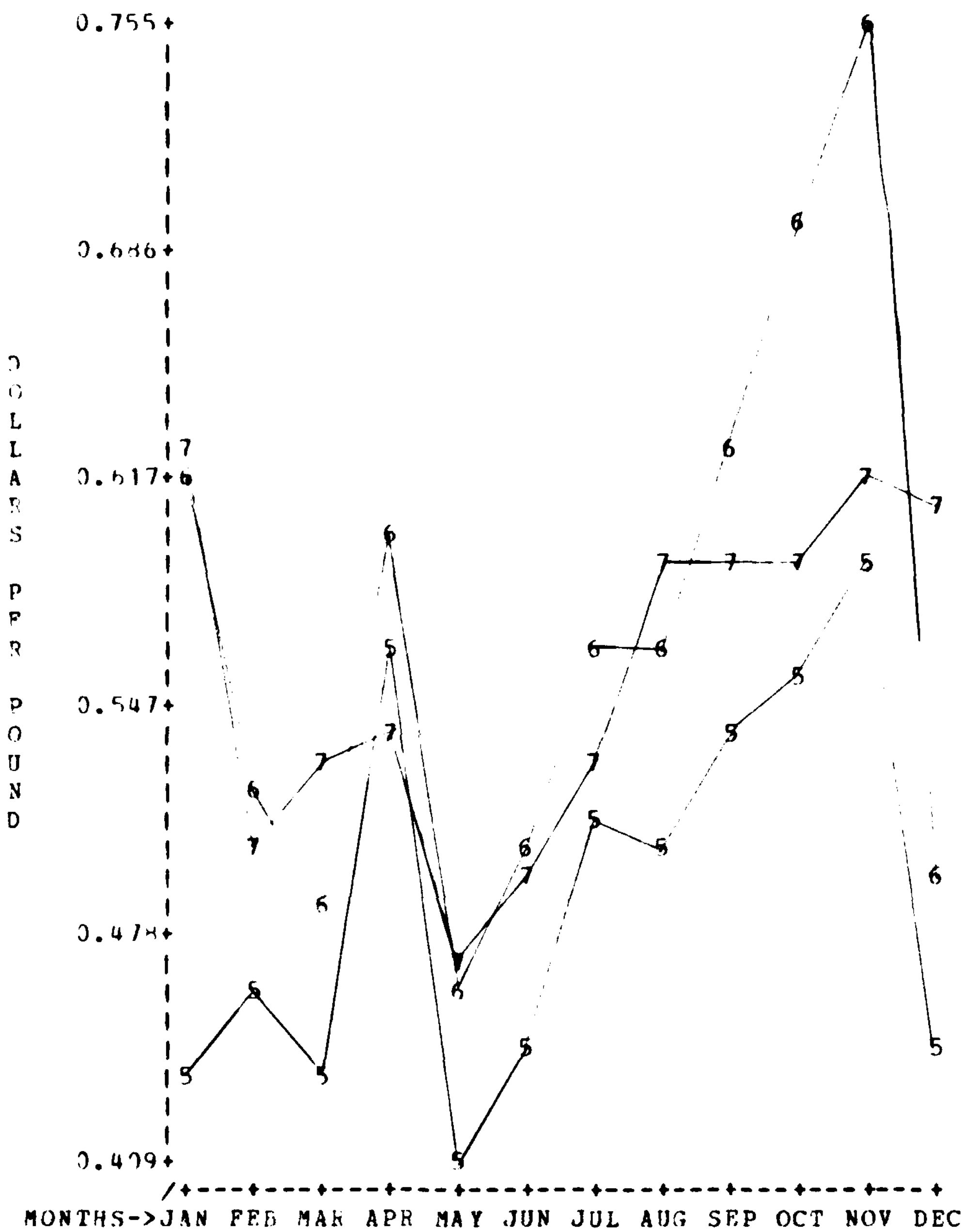

FIGURE 8. RAW STRAWBERRY PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

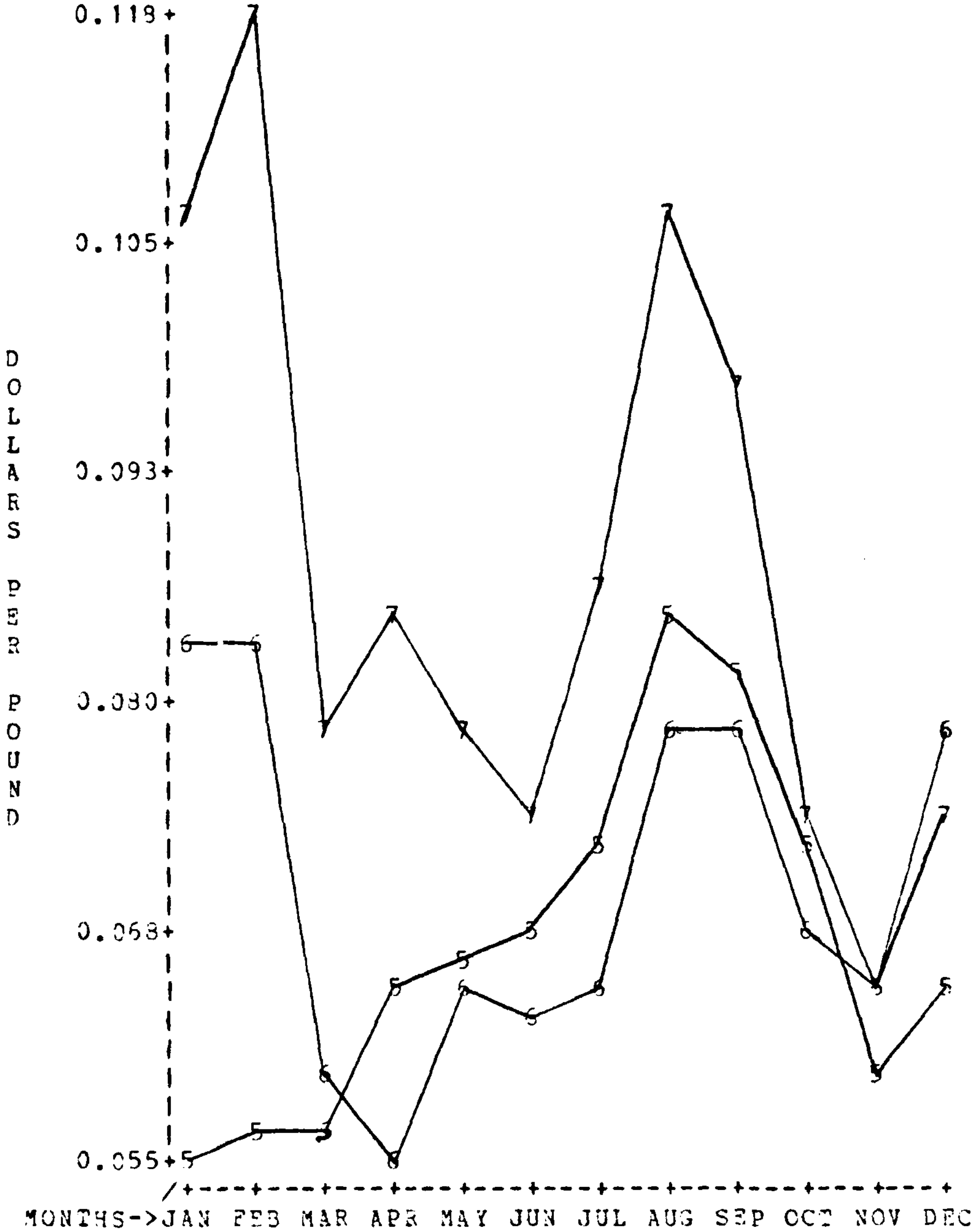

FIGURE 9. RAW MUSTARD GREEN PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

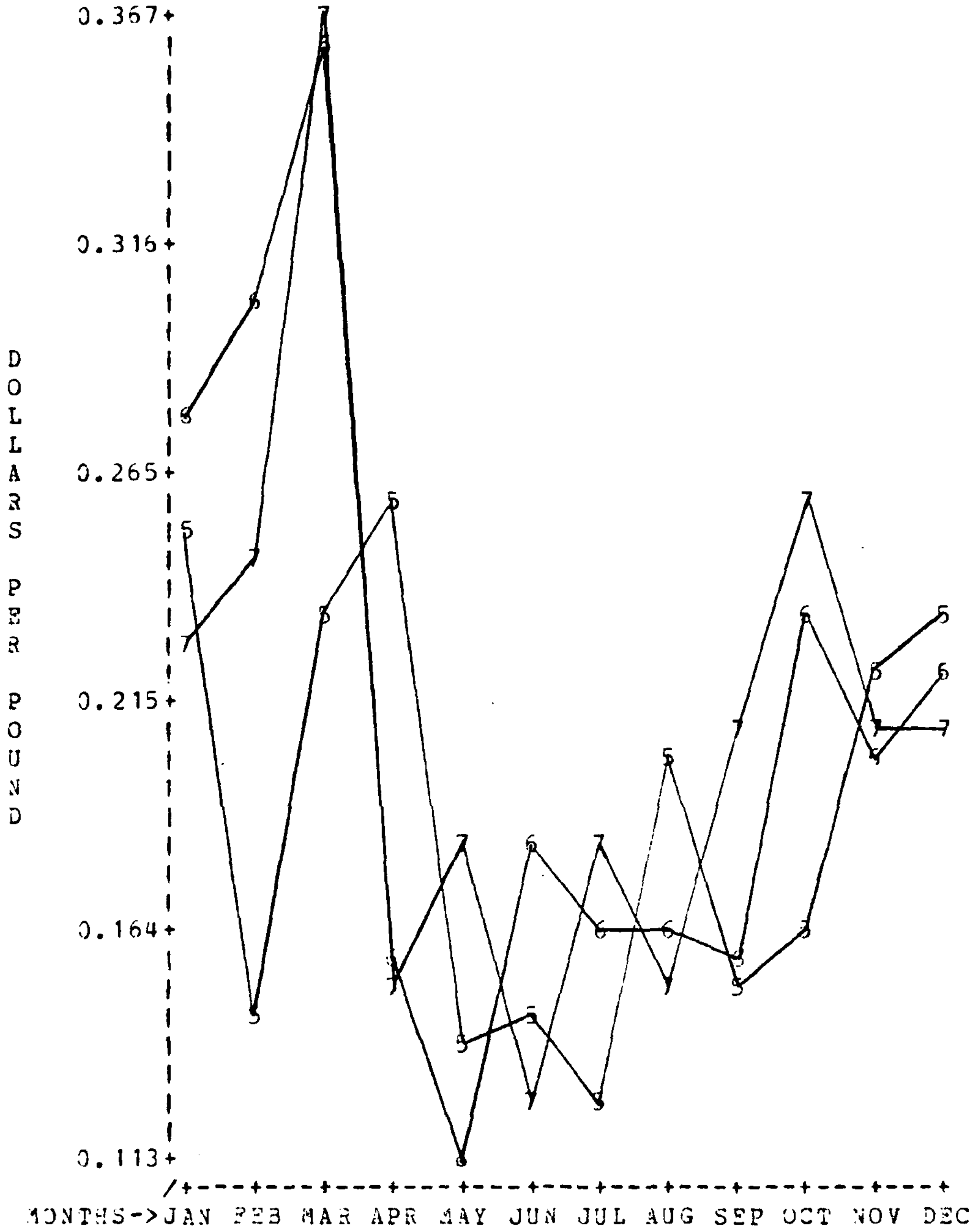

FIGURE 10. RAW SQUASH PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

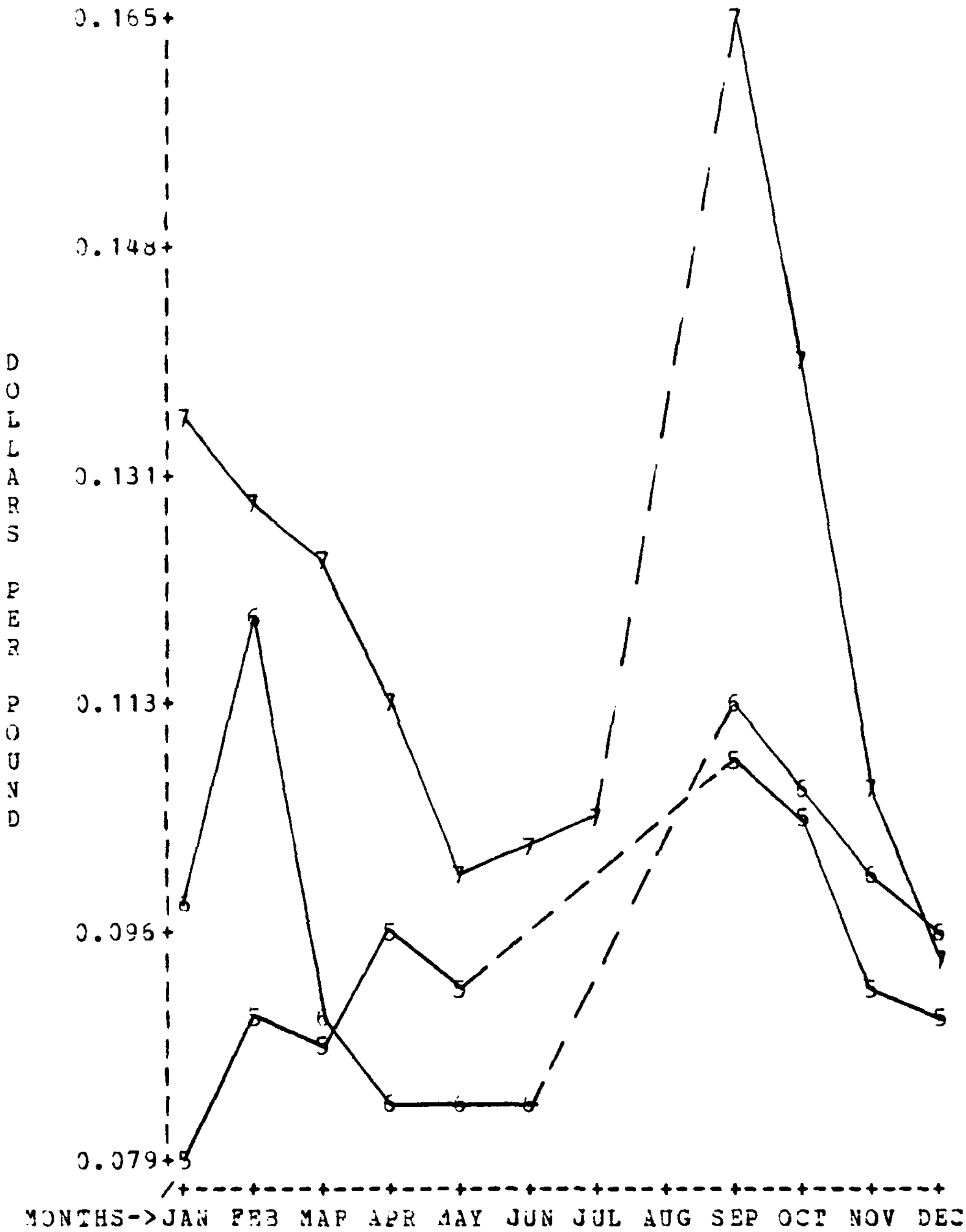

FIGURE 11. RAW TURNIP PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

Dotted line indicates no price data available

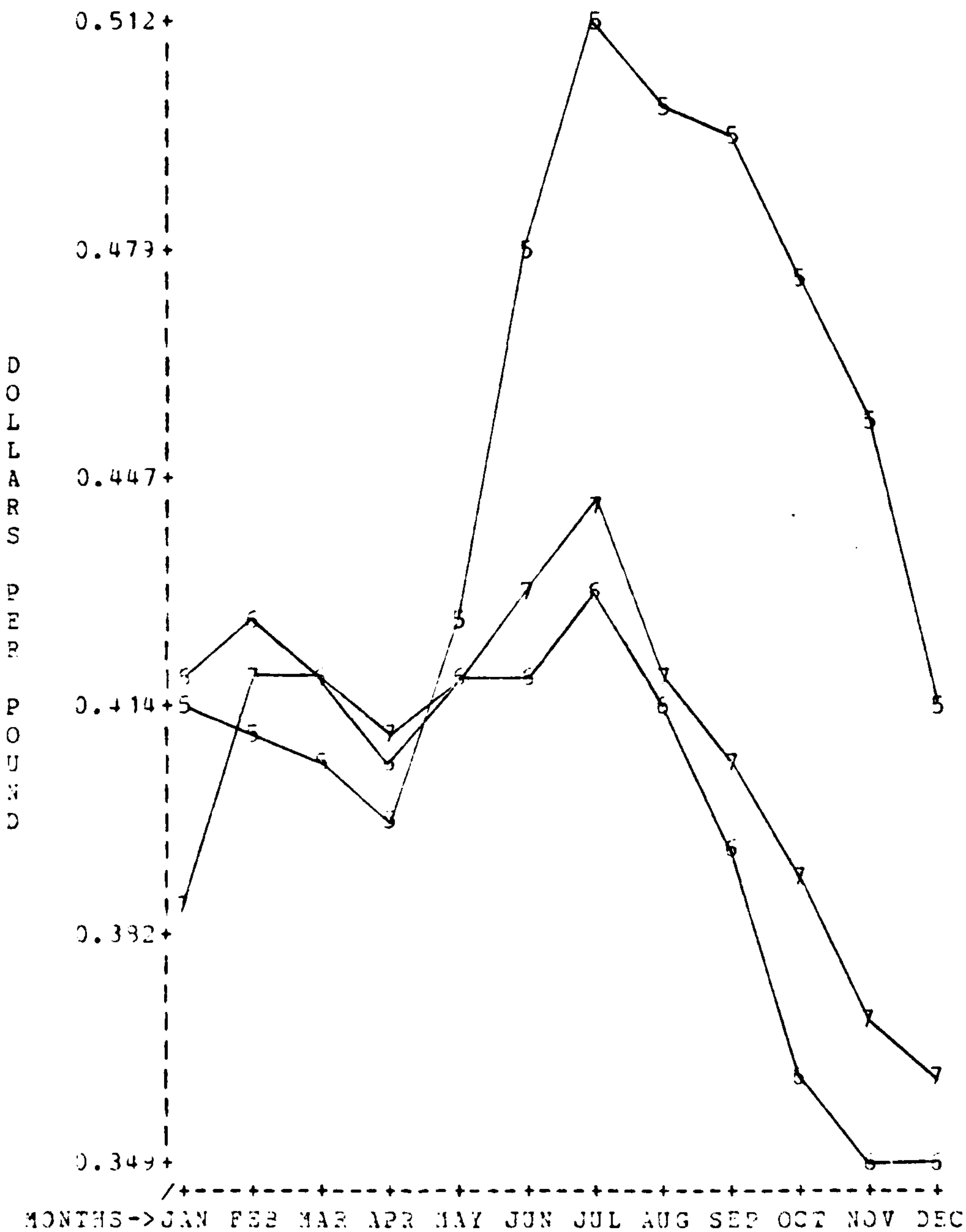

FIGURE 12. PROCESSED CHICKEN PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

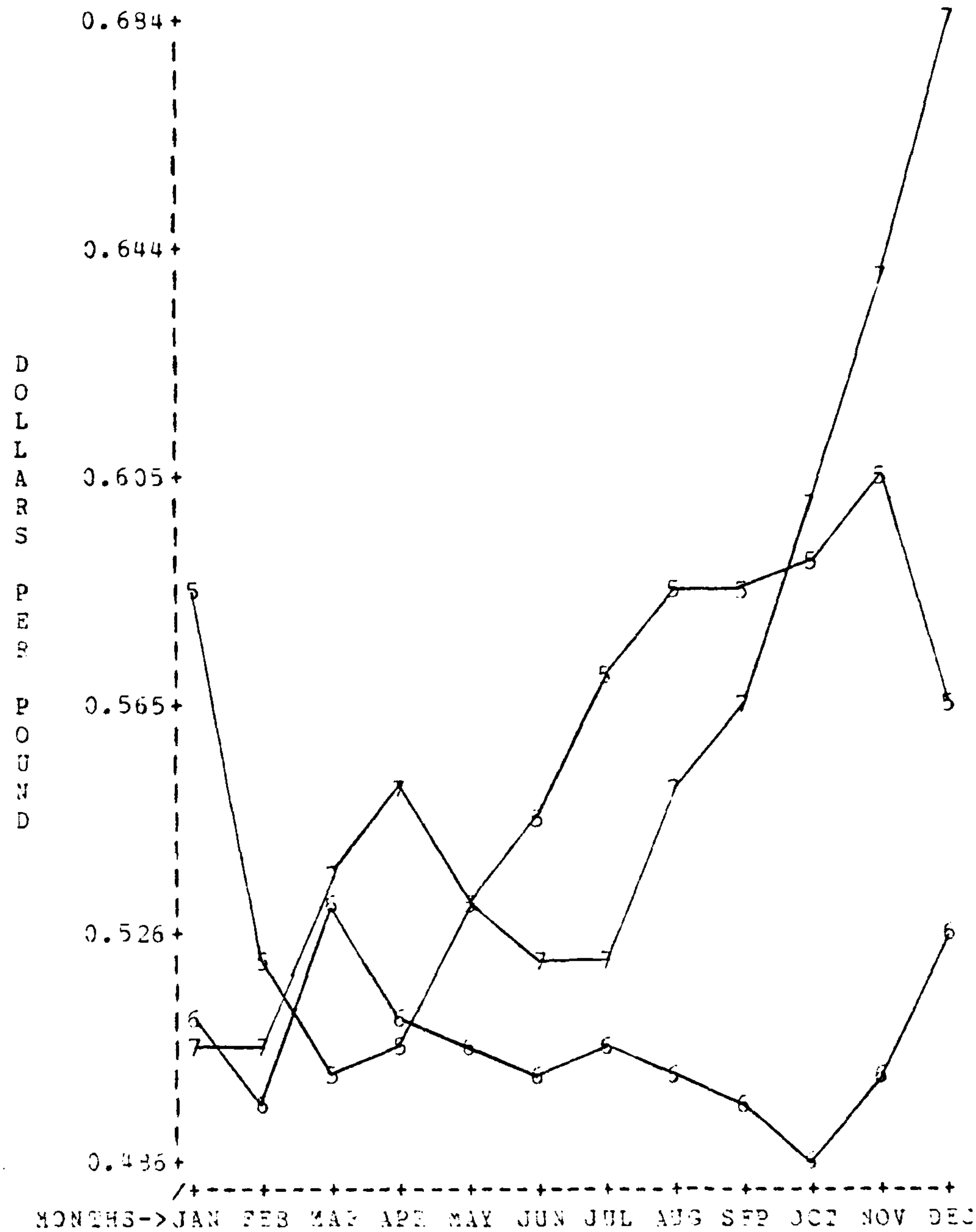

FIGURE 13. PROCESSED TURKEY PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

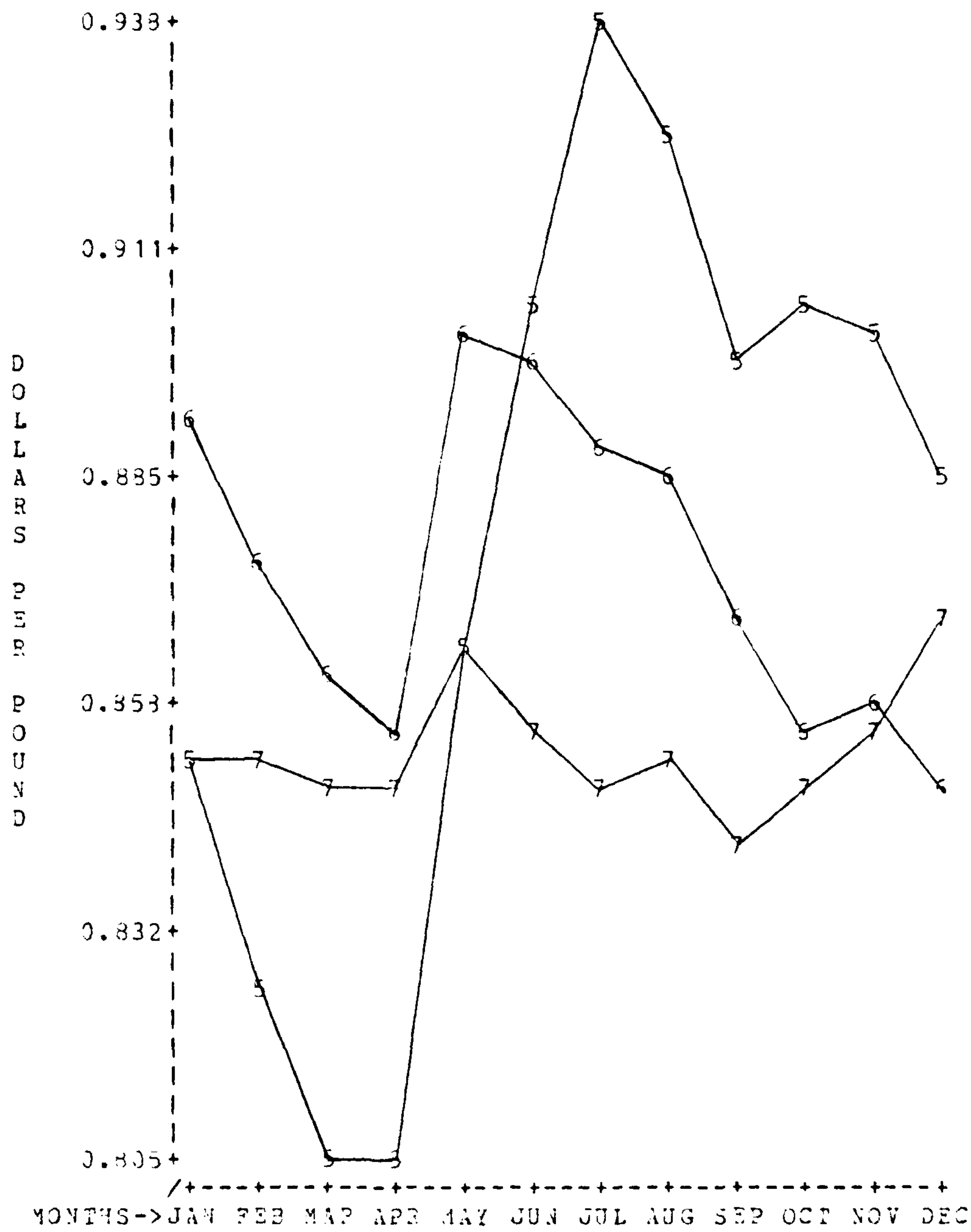

FIGURE 14. PROCESSED HAMBURGER PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

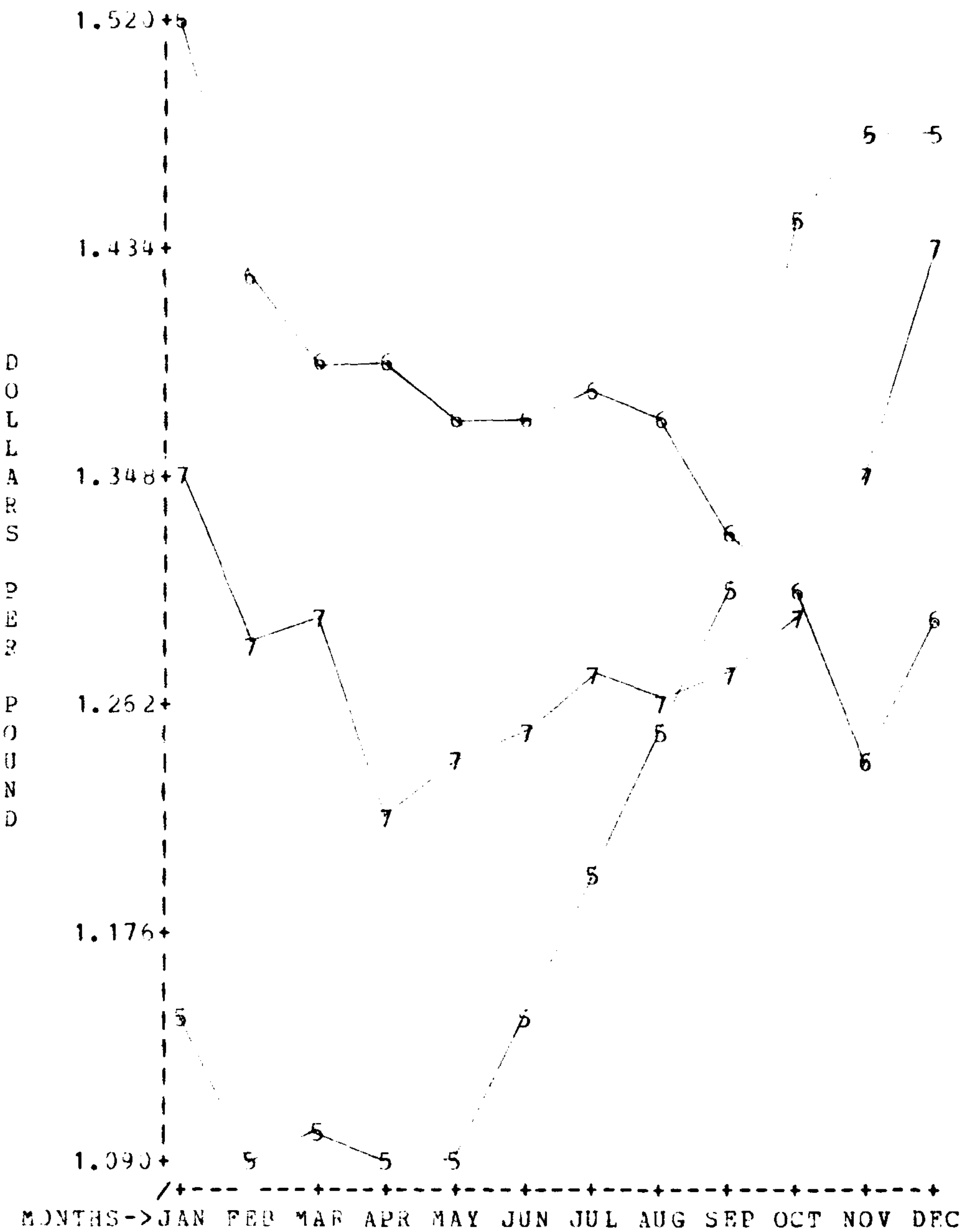

FIGURE 15. PROCESSED HAM PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

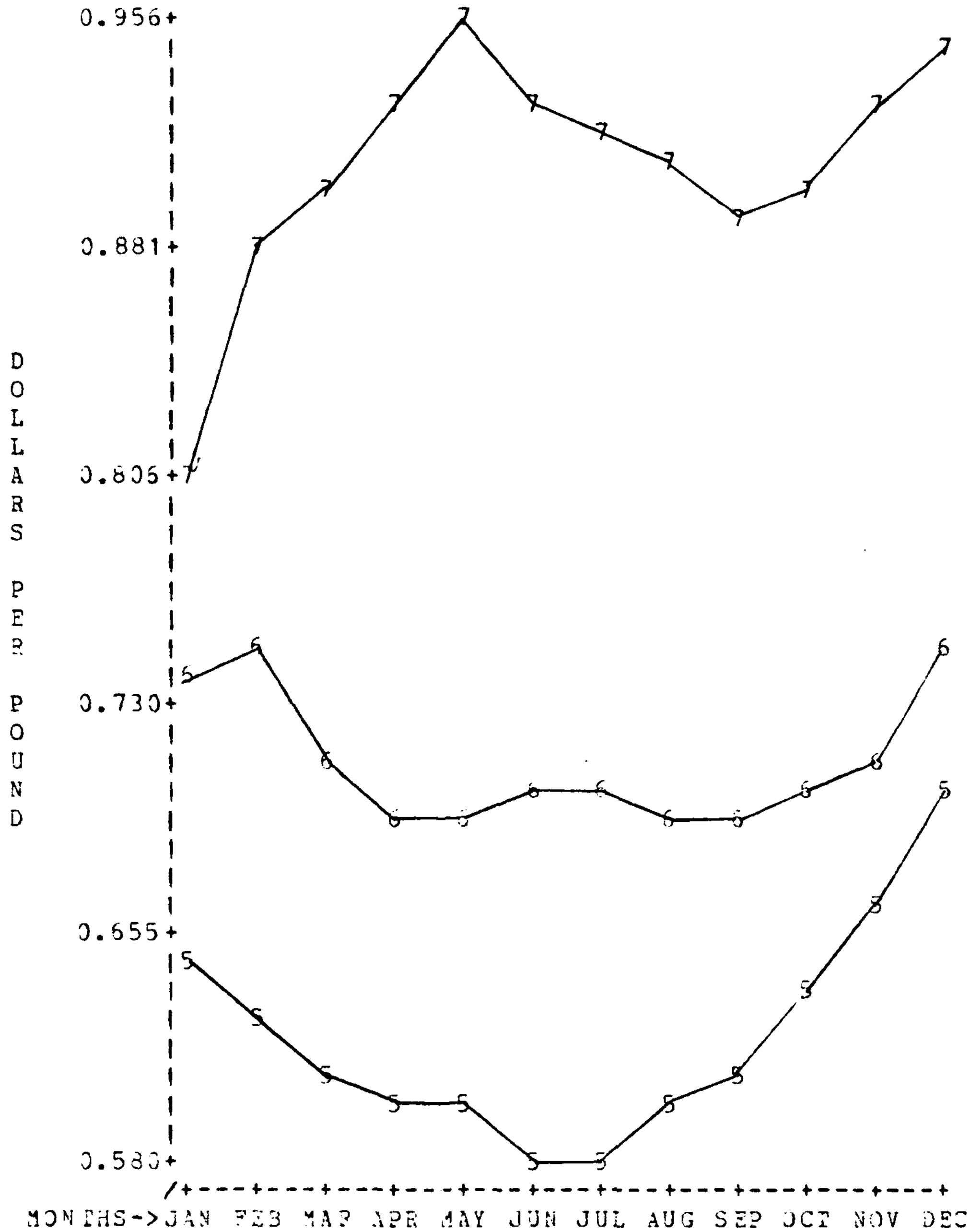

FIGURE 16. FROZEN COD FILLET PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

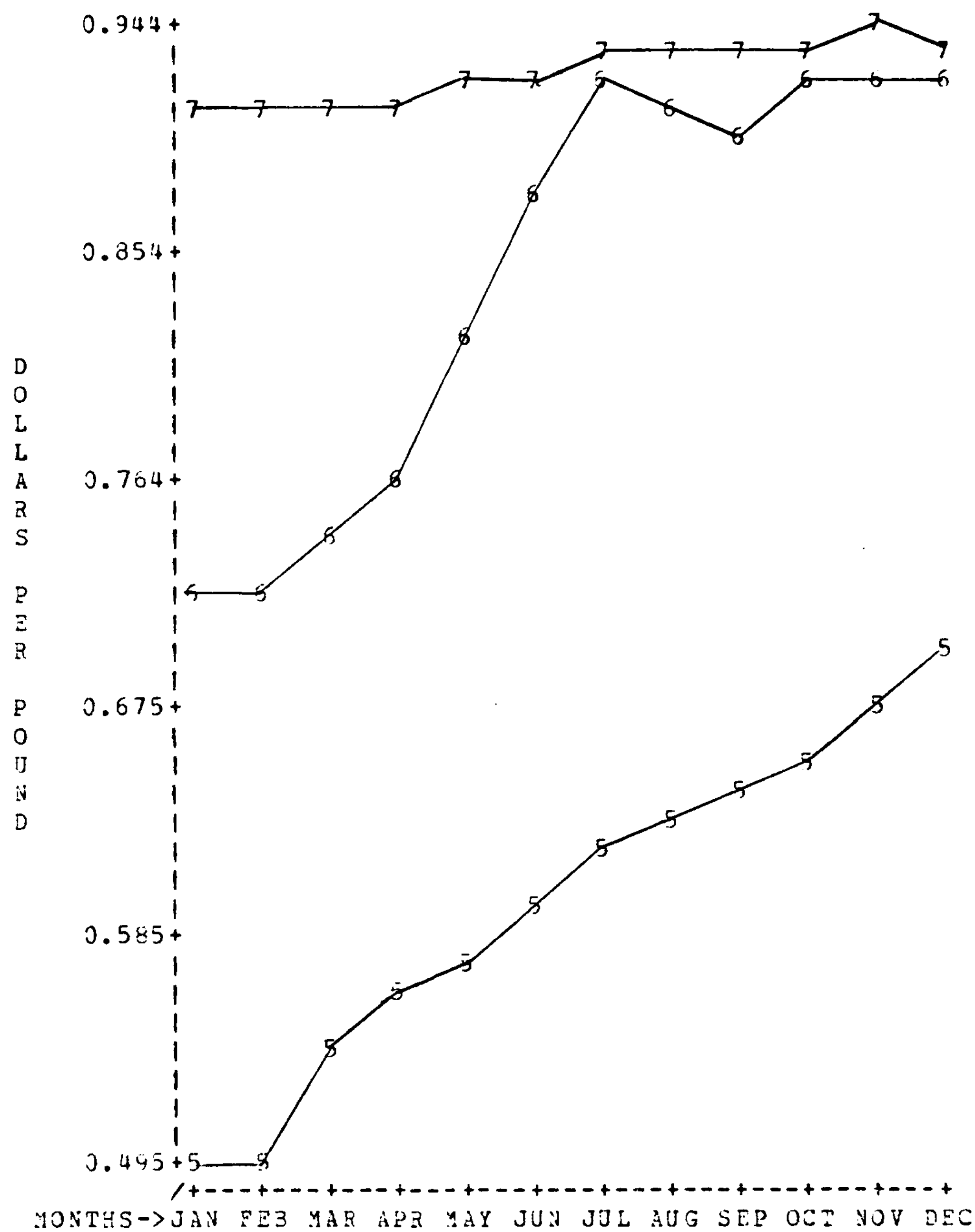

FIGURE 17. FROZEN PERCH FILLET PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

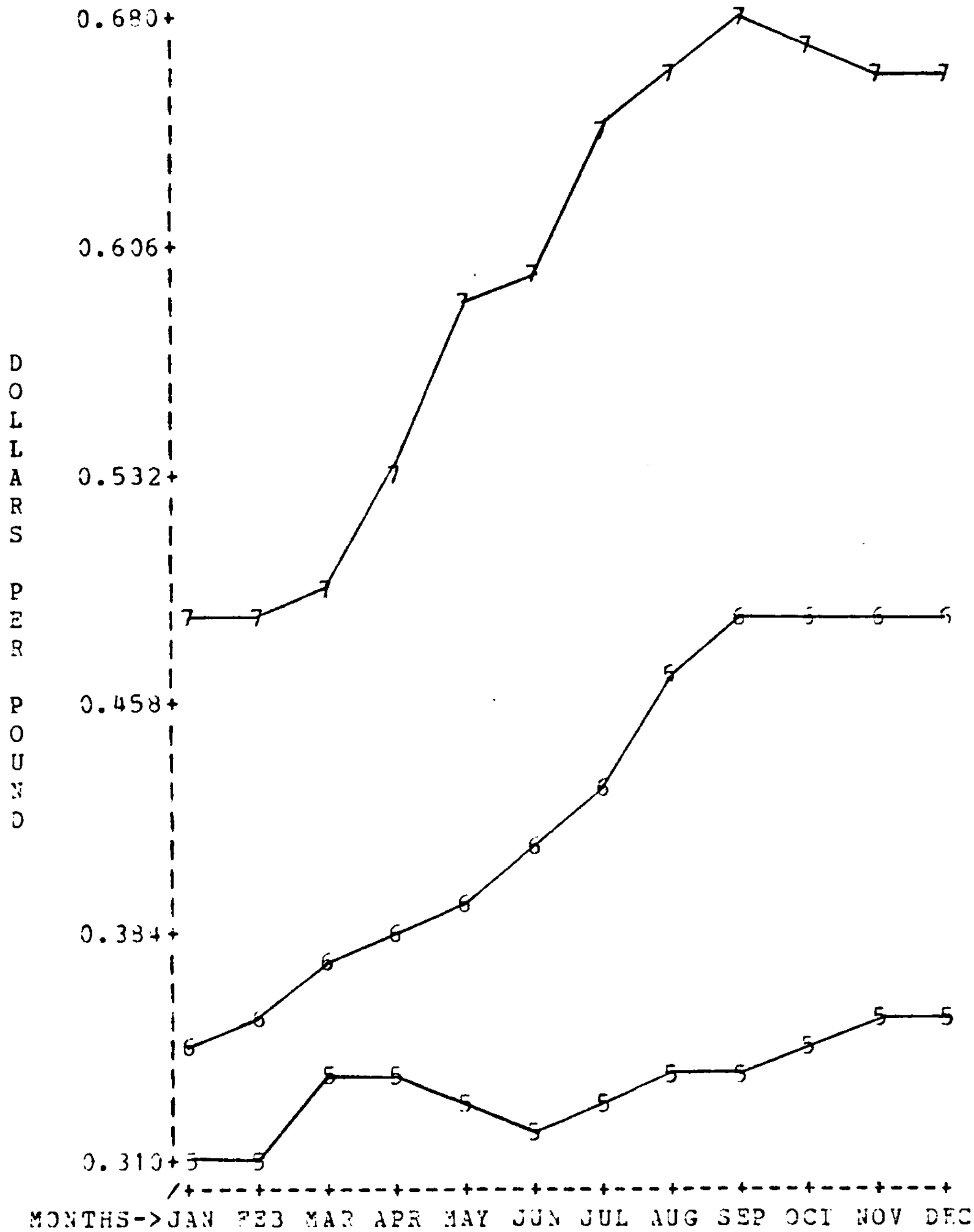

FIGURE 16. FROZEN BLOCK POLLOCK PRICES

7 = PRICES FOR YEAR 1977
6 = PRICES FOR YEAR 1976
5 = PRICES FOR YEAR 1975

B. COMPUTER DATA FOR DRY GOODS MODEL

```
//RAY JOB (IE239,7R),'RAYDROGAN',MSGLEVEL=1,REGION=512K
/*JOBPARM TIME=159,LINES=10K
/*ROUTE  PRINT RMT9
//* THIS IS MP3X5:  MIN INTEGER SOLUTION OF DRY GOODS
// EXEC MPSX
//MPSCOMP.SYSIN DD *
         PROGRAM
         TITLE('A.U.FOOD SERVICES')
         INITIALZ
         MOVE(XDATA,'DATA1')
         MOVE(XPBNAME,'BEST BUY')
         CONVERT('SUMMARY')
         SETUP('MIN','BOUNDS','BOND')
         PICTURE
         BCDOUT
         MOVE(XRHS,'CASES')
         MOVE(XOBJ,'OBJFUN')
         PRIMAL
         SOLUTION
         OPTIMIX
         EXIT
         PEND
//MPSEXEC.ETA1 DD SPACE=(CYL,(1,1))
//MPSEXEC.ETA2 DD SPACE=(CYL,(1,1))
//MPSEXEC.MATRIX1 DD SPACE=(CYL,(1,1))
//MPSEXEC.SCRATCH1 DD SPACE=(CYL,(1,1))
//MPSEXEC.SCRATCH2 DD SPACE=(CYL,(1,1))
//MPSEXEC.PROBFILE DD SPACE=(CYL,(1,1))
//MPSEXEC.MIXWORK  DD SPACE=(CYL,(1,1)),UNIT=SYSDA
//MPSEXEC.SYSIN DD *
NAME          DATA1
ROWS
 N  OBJFUN
 L  R10
 L  R11
 L  R12
 L  R13
 L  R14
 L  R15
 L  R16
 L  R17
 L  R18
```

L	R19
L	R20
L	R21
E	R22
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E	R24
E	R25
E	R26
E	R27
E	R28
E	R29
E	R30
E	R31
E	R32
F	R33
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E R114
E R115
E R116
E R117
E R118
E R119
E R120
E R121
E R122

```
 E  R123
 E  R124
 E  R125
 E  R126
 E  R127
 E  R128
 E  R129
COLUMNS
    INTEG1    'MARKER'                        'INTORG'
    C1        OBJFUN        7.092
    C1        R10           0.9368         R22              1.
    C2        OBJFUN        7.128
    C2        R11           0.9368         R23              1.
    C3        OBJFUN        7.416
    C3        R12            .9368         R24              1.
    C4        OBJFUN        8.064
    C4        R13            .9368         R25              1.
    C5        OBJFUN        8.604
    C5        R14            .9368         R26              1.
    C6        OBJFUN        9.180
    C6        R15            .9368         R27              1.
    C7        OBJFUN        9.864
    C7        R16            .9368         R28              1.
    C8        OBJFUN        9.828
    C8        R17            .9368         R29              1.
    C9        OBJFUN        9.072
    C9        R18            .9368         R30              1.
    C10       OBJFUN        8.676
    C10       R19            .9368         R31              1.
    C11       OBJFUN        8.028
    C11       R20            .9368         R32              1.
    C12       OBJFUN        7.812
    C12       R21            .9368         R33              1.
    C13       OBJFUN        7.905
    C13       R10            .9368         R34              1.
    C14       OBJFUN        7.945
    C14       R11            .9368         R35              1.
    C15       OBJFUN        8.266
    C15       R12            .9368         R36              1.
    C16       OBJFUN        8.988
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    C17       OBJFUN        9.590
    C17       R14            .9368         R38              1.
    C18       OBJFUN       10.232
    C18       R15            .9368         R39              1.
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    C19       R16            .9368         R40              1.
    C20       OBJFUN       10.954
    C20       R17            .9368         R41              1.
    C21       OBJFUN       10.112
    C21       R18            .9368         R42              1.
    C22       OBJFUN        9.670
```

C22	R19	.9368	R43	1.
C23	OBJFUN	8.948		
C23	R20	.9368	R44	1.
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C24	R21	.9368	R45	1.
C25	OBJFUN	7.000		
C25	R10	.9368	R46	1.
C26	OBJFUN	7.000		
C26	R11	.9368	R47	1.
C27	OBJFUN	7.000		
C27	R12	.9368	R48	1.
C28	OBJFUN	7.000		
C28	R13	.9368	R49	1.
C29	OBJFUN	6.532		
C29	R14	.9368	R50	1.
C30	OBJFUN	5.016		
C30	R15	.9368	R51	1.
C31	OBJFUN	4.134		
C31	R16	.9368	R52	1.
C32	OBJFUN	5.264		
C32	R17	.9368	R53	1.
C33	OBJFUN	7.000		
C33	R18	.9368	R54	1.
C34	OBJFUN	7.000		
C34	R19	.9368	R55	1.
C35	OBJFUN	7.000		
C35	R20	.9368	R56	1.
C36	OBJFUN	7.000		
C36	R21	.9368	R57	1.
C37	OBJFUN	7.029		
C37	R10	.9584	R58	1.
C38	OBJFUN	7.562		
C38	R11	.9584	R59	1.
C39	OBJFUN	7.562		
C39	R12	.9584	R60	1.
C40	OBJFUN	7.881		
C40	R13	.9584	R61	1.
C41	OBJFUN	8.946		
C41	R14	.9584	R62	1.
C42	OBJFUN	10.331		
C42	R15	.9584	R63	1.
C43	OBJFUN	8.840		
C43	R16	.9584	R64	1.
C44	OBJFUN	6.497		
C44	R17	.9584	R65	1.
C45	OBJFUN	6.603		
C45	R18	.9584	R66	1.
C46	OBJFUN	7.029		
C46	R19	.9584	R67	1.
C47	OBJFUN	6.923		
C47	R20	.9584	R68	1.
C48	OBJFUN	6.816		

C48	R21	.9584	R69	1.
C49	OBJFUN	2.178		
C49	R10	.9368	R70	1.
C50	OBJFUN	2.343		
C50	R11	.9368	R71	1.
C51	OBJFUN	2.343		
C51	R12	.9368	R72	1.
C52	OBJFUN	2.442		
C52	R13	.9368	R73	1.
C53	OBJFUN	2.772		
C53	R14	.9368	R74	1.
C54	OBJFUN	3.201		
C54	R15	.9368	R75	1.
C55	OBJFUN	2.739		
C55	R16	.9368	R76	1.
C56	OBJFUN	2.013		
C56	R17	.9368	R77	1.
C57	OBJFUN	2.046		
C57	R18	.9368	R78	1.
C58	OBJFUN	2.178		
C58	R19	.9368	R79	1.
C59	OBJFUN	2.145		
C59	R20	.9368	R80	1.
C60	OBJFUN	2.112		
C60	R21	.9368	R81	1.
C61	OBJFUN	2.906		
C61	R10	.9703	R82	1.0
C62	OBJFUN	2.930		
C62	R11	.9703	R83	1.0
C63	OBJFUN	3.185		
C63	R12	0.9703	R84	1.0
C64	OBJFUN	3.720		
C64	R13	0.9703	R85	1.0
C65	OBJFUN	4.836		
C65	R14	0.9703	R86	1.0
C66	OBJFUN	5.650		
C66	R15	0.9703	R87	1.0
C67	OBJFUN	5.441		
C67	R16	0.9703	R88	1.0
C68	OBJFUN	4.627		
C68	R17	0.9703	R89	1.0
C69	OBJFUN	3.278		
C69	R18	0.9703	R90	1.0
C70	OBJFUN	2.976		
C70	R19	0.9703	R91	1.0
C71	OBJFUN	3.023		
C71	R20	0.9703	R92	1.0
C72	OBJFUN	3.348		
C72	R21	0.9703	R93	1.0
C73	OBJFUN	7.583		
C73	R10	1.0040	R94	1.0
C74	OBJFUN	6.394		

C74	R11	1.0040	R95	1.0
C75	OBJFUN	7.449		
C75	R12	1.0040	R96	1.0
C76	OBJFUN	5.205		
C76	R13	1.0040	R97	1.0
C77	OBJFUN	5.542		
C77	R14	1.0040	R98	1.0
C78	OBJFUN	5.654		
C78	R15	1.0040	R99	1.0
C79	OBJFUN	4.510		
C79	R16	1.0040	R100	1.0
C80	OBJFUN	5.273		
C80	R17	1.0040	R101	1.0
C81	OBJFUN	5.519		
C81	R18	1.0040	R102	1.0
C82	OBJFUN	6.058		
C82	R19	1.0040	R103	1.0
C83	OBJFUN	6.327		
C83	R20	1.0040	R104	1.0
C84	OBJFUN	5.901		
C84	R21	1.0040	R105	1.0
C85	OBJFUN	4.037		
C85	R10	0.9057	R106	1.0
C86	OBJFUN	4.011		
C86	R11	0.9057	R107	1.0
C87	OBJFUN	3.390		
C87	R12	0.9057	R108	1.0
C88	OBJFUN	3.364		
C88	R13	0.9057	R109	1.0
C89	OBJFUN	3.441		
C89	R14	0.9057	R110	1.0
C90	OBJFUN	3.623		
C90	R15	0.9057	R111	1.0
C91	OBJFUN	3.623		
C91	R16	0.9057	R112	1.0
C92	OBJFUN	3.234		
C92	R17	0.9057	R113	1.0
C93	OBJFUN	3.312		
C93	R18	0.9057	R114	1.0
C94	OBJFUN	3.545		
C94	R19	0.9057	R115	1.0
C95	OBJFUN	3.416		
C95	R20	0.9057	R116	1.0
C96	OBJFUN	3.623		
C96	R21	0.9057	R117	1.0
C97	OBJFUN	5.427		
C97	R10	0.9703	R118	1.0
C98	OBJFUN	6.588		
C98	R11	0.9703	R119	1.0
C99	OBJFUN	7.533		
C99	R12	0.9703	R120	1.0
C100	OBJFUN	7.128		

C100	R13	0.9703	R121	1.0
C101	OBJFUN	5.211		
C101	R14	0.9703	R122	1.0
C102	OBJFUN	5.940		
C102	R15	0.9703	R123	1.0
C103	OBJFUN	5.778		
C103	R16	0.9703	R124	1.0
C104	OBJFUN	5.238		
C104	R17	0.9703	R125	1.0
C105	OBJFUN	4.779		
C105	R18	0.9703	R126	1.0
C106	OBJFUN	4.536		
C106	R19	0.9703	R127	1.0
C107	OBJFUN	5.049		
C107	R20	0.9703	R128	1.0
C108	OBJFUN	6.372		
C108	R21	0.9703	R129	1.0
INTEG2	'MARKER'		'INTEND'	
C109	R11	0.9368	R22	-1.0
C109	R23	1.0		
C110	R12	0.9368	R23	-1.0
C110	R24	1.0		
C111	R13	0.9368	R24	-1.
C111	R25	1.0		
C112	R14	0.9368	R25	-1.
C112	R26	1.0		
C113	R15	0.9368	R26	-1.
C113	R27	1.0		
C114	R16	0.9368	R27	-1.
C114	R28	1.0		
C115	R17	0.9368	R28	-1.
C115	R29	1.0		
C116	R18	0.9368	R29	-1.
C116	R30	1.0		
C117	R19	0.9368	R30	-1.
C117	R31	1.0		
C118	R20	0.9368	R31	-1.
C118	R32	1.0		
C119	R21	0.9368	R32	-1.
C119	R33	1.0		
C120	R10	0.9368	R22	1.
C120	R33	-1.0		
C121	R11	0.9368	R34	-1.
C121	R35	1.0		
C122	R12	0.9368	R35	-1.
C122	R36	1.0		
C123	R13	0.9368	R36	-1.
C123	R37	1.0		
C124	R14	0.9368	R37	-1.
C124	R38	1.0		
C125	R15	0.9368	R38	-1.
C125	R39	1.0		

C126	R16	0.9368	R39	-1.
C126	R40	1.0		
C127	R17	0.9368	R40	-1.
C127	R41	1.0		
C128	R18	0.9368	R41	-1.
C128	R42	1.0		
C129	R19	0.9368	R42	-1.
C129	R43	1.0		
C130	R20	0.9368	R43	-1.
C130	R44	1.0		
C131	R21	0.9368	R44	-1.
C131	R45	1.0		
C132	R10	0.9368	R34	1.
C132	R45	-1.0		
C133	R11	0.9368	R46	-1.
C133	R47	1.0		
C134	R12	0.9368	R47	-1.
C134	R48	1.0		
C135	R13	0.9368	R48	-1.
C135	R49	1.0		
C136	R14	0.9368	R49	-1.
C136	R50	1.0		
C137	R15	0.9368	R50	-1.
C137	R51	1.0		
C138	R16	0.9368	R51	-1.
C138	R52	1.0		
C139	R17	0.9368	R52	-1.
C139	R53	1.0		
C140	R18	0.9368	R53	-1.
C140	R54	1.0		
C141	R19	0.9368	R54	-1.
C141	R55	1.0		
C142	R20	0.9368	R55	-1.
C142	R56	1.0		
C143	R21	0.9368	R56	-1.
C143	R57	1.0		
C144	R10	0.9368	R46	1.
C144	R57	-1.0		
C145	R11	0.9584	R58	-1.
C145	R59	1.0		
C146	R12	0.9584	R59	-1.
C146	R60	1.0		
C147	R13	0.9584	R60	-1.
C147	R61	1.0		
C148	R14	0.9584	R61	-1.
C148	R62	1.0		
C149	R15	0.9584	R62	-1.
C149	R63	1.0		
C150	R16	0.9584	R63	-1.
C150	R64	1.0		
C151	R17	0.9584	R64	-1.
C151	R65	1.0		

C152	R18	0.9584	R65	-1.
C152	R66	1.0		
C153	R19	0.9584	R66	-1.
C153	R67	1.0		
C154	R20	0.9584	R67	-1.
C154	R68	1.0		
C155	R21	0.9584	R68	-1.
C155	R69	1.0		
C156	R10	0.9584	R58	1.
C156	R69	-1.0		
C157	R11	0.9368	R70	-1.
C157	R71	1.0		
C158	R12	0.9368	R71	-1.
C158	R72	1.0		
C159	R13	0.9368	R72	-1.
C159	R73	1.0		
C160	R14	0.9368	R73	-1.
C160	R74	1.0		
C161	R15	0.9368	R74	-1.
C161	R75	1.0		
C162	R16	0.9368	R75	-1.
C162	R76	1.0		
C163	R17	0.9368	R76	-1.
C163	R77	1.0		
C164	R18	0.9368	R77	-1.
C164	R78	1.0		
C165	R19	0.9368	R78	-1.
C165	R79	1.0		
C166	R20	0.9368	R79	-1.
C166	R80	1.0		
C167	R21	0.9368	R80	-1.
C167	R81	1.0		
C168	R10	0.9368	R70	1.
C168	R81	-1.0		
C169	R11	0.9703	R82	-1.
C169	R83	1.0		
C170	R12	0.9703	R83	-1.
C170	R84	1.0		
C171	R13	0.9703	R84	-1.
C171	R85	1.0		
C172	R14	0.9703	R85	-1.
C172	R86	1.0		
C173	R15	0.9703	R86	-1.
C173	R87	1.0		
C174	R16	0.9703	R87	-1.
C174	R88	1.0		
C175	R17	0.9703	R88	-1.
C175	R89	1.0		
C176	R18	0.9703	R89	-1.
C176	R90	1.0		
C177	R19	0.9703	R90	-1.
C177	R91	1.0		

AD-A090 763 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH F/G 6/8
A GENERAL MODEL FOR FOOD PURCHASING IN CAPTIVE FOOD SERVICE INS--ETC(U)
AUG 79 R A DROGAN
UNCLASSIFIED AFIT-79-186T NL

END
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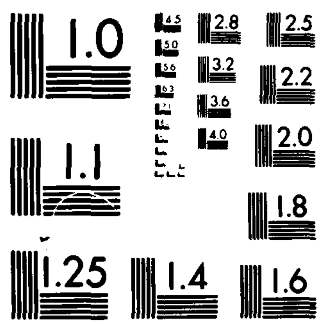

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

C178	R20	0.9703	R91	-1.
C178	R92	1.0		
C179	R21	0.9703	R92	-1.
C179	R93	1.0		
C180	R10	0.9703	R82	1.
C180	R93	-1.0		
C181	R11	1.0040	R94	-1.
C181	R95	1.0		
C182	R12	1.0040	R95	-1.
C182	R96	1.0		
C183	R13	1.0040	R96	-1.
C183	R97	1.0		
C184	R14	1.0040	R97	-1.
C184	R98	1.0		
C185	R15	1.0040	R98	-1.
C185	R99	1.0		
C186	R16	1.0040	R99	-1.
C186	R100	1.0		
C187	R17	1.0040	R100	-1.
C187	R101	1.0		
C188	R18	1.0040	R101	-1.
C188	R102	1.0		
C189	R19	1.0040	R102	-1.
C189	R103	1.0		
C190	R20	1.0040	R103	-1.
C190	R104	1.0		
C191	R21	1.0040	R104	-1.
C191	R105	1.0		
C192	R10	1.0040	R94	1.
C192	R105	-1.0		
C193	R11	0.9057	R106	-1.
C193	R107	1.0		
C194	R12	0.9057	R107	-1.
C194	R108	1.0		
C195	R13	0.9057	R108	-1.
C195	R109	1.0		
C196	R14	0.9057	R109	-1.
C196	R110	1.0		
C197	R15	0.9057	R110	-1.
C197	R111	1.0		
C198	R16	0.9057	R111	-1.
C198	R112	1.0		
C199	R17	0.9057	R112	-1.
C199	R113	1.0		
C200	R18	0.9057	R113	-1.
C200	R114	1.0		
C201	R19	0.9057	R114	-1.
C201	R115	1.0		
C202	R20	0.9057	R115	-1.
C202	R116	1.0		
C203	R21	0.9057	R116	-1.
C203	R117	1.0		

	C204	R10	0.9057	R106	1.
	C204	R117	-1.0		
	C205	R11	0.9703	R118	-1.
	C205	R119	1.0		
	C206	R12	0.9703	R119	-1.
	C206	R120	1.0		
	C207	R13	0.9703	R120	-1.
	C207	R121	1.0		
	C208	R14	0.9703	R121	-1.
	C208	R122	1.0		
	C209	R15	0.9703	R122	-1.
	C209	R123	1.0		
	C210	R16	0.9703	R123	-1.
	C210	R124	1.0		
	C211	R17	0.9703	R124	-1.
	C211	R125	1.0		
	C212	R18	0.9703	R125	-1.
	C212	R126	1.0		
	C213	R19	0.9703	R126	-1.
	C213	R127	1.0		
	C214	R20	0.9703	R127	-1.
	C214	R128	1.0		
	C215	R21	0.9703	R128	-1.
	C215	R129	1.0		
	C216	R10	0.9703	R118	1.
	C216	R129	-1.0		
RHS					
	CASES	R10	4500.		
	CASES	R11	4500.	R12	4500.
	CASES	R13	4500.	R14	4500.
	CASES	R15	4500.	R16	4500.
	CASES	R17	4500.	R18	4500.
	CASES	R19	4500.	R20	4500.
	CASES	R21	4500.	R22	27.
	CASES	R23	27.	R24	24.
	CASES	R25	65.	R26	68.
	CASES	R27	48.	R28	63.
	CASES	R29	55.	R30	23.
	CASES	R31	70.	R32	68.
	CASES	R33	18.	R34	13.
	CASES	R35	14.	R36	10.
	CASES	R37	15.	R38	15.
	CASES	R39	7.	R40	7.
	CASES	R41	7.	R42	6.
	CASES	R43	19.	R44	19.
	CASES	R45	5.	R46	57.
	CASES	R47	57.	R48	39.
	CASES	R49	48.	R50	49.
	CASES	R51	36.	R52	48.
	CASES	R53	42.	R54	34.
	CASES	R55	105.	R56	101.
	CASES	R57	27.	R58	59.

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          CASES     R59          59.          R60          41.
          CASES     R61          52.          R62          54.
          CASES     R63          34.          R64          42.
          CASES     R65          36.          R66          29.
          CASES     R67          89.          R68          86.
          CASES     R69          23.          R70          39.
          CASES     R71          38.          R72          27.
          CASES     R73          35.          R74          36.
          CASES     R75          27.          R76          36.
          CASES     R77          31.          R78          18.
          CASES     R79          56.          R80          54.
          CASES     R81          14.          R82          23.
          CASES     R83          23.          R84          15.
          CASES     R85          18.          R86          18.
          CASES     R87           9.          R88          10.
          CASES     R89           8.          R90          10.
          CASES     R91          30.          R92          29.
          CASES     R93           8.          R94         379.
          CASES     R95         379.          R96         261.
          CASES     R97         330.          R98         340.
          CASES     R99         179.          R100        198.
          CASES     R101        172.          R102        164.
          CASES     R103        507.          R104        491.
          CASES     R105        131.          R106         50.
          CASES     R107         50.          R108         35.
          CASES     R109         42.          R110         43.
          CASES     R111         23.          R112         26.
          CASES     R113         23.          R114         22.
          CASES     R115         69.          R116         66.
          CASES     R117         18.          R118         89.
          CASES     R119         89.          R120         60.
          CASES     R121         65.          R122         68.
          CASES     R123         46.          R124         61.
          CASES     R125         53.          R126         40.
          CASES     R127        124.          R128        120.
          CASES     R129         32.
     BOUNDS
      UP BOND       C1          556.
      UP BOND       C2          556.
      UP BOND       C3          556.
      UP BOND       C4          556.
      UP BOND       C5          556.
      UP BOND       C6          556.
      UP BOND       C7          556.
      UP BOND       C8          556.
      UP BOND       C9          556.
      UP BOND       C10         556.
      UP BOND       C11         556.
      UP BOND       C12         556.
      UP BOND       C13         137.
      UP BOND       C14         137.
      UP BOND       C15         137.
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UP BOND	C16	137.
UP BOND	C17	137.
UP BOND	C18	137.
UP BOND	C19	137.
UP BOND	C20	137.
UP BOND	C21	137.
UP BOND	C22	137.
UP BOND	C23	137.
UP BOND	C24	137.
UP BOND	C25	643.
UP BOND	C26	643.
UP BOND	C27	643.
UP BOND	C28	643.
UP BOND	C29	643.
UP BOND	C30	643.
UP BOND	C31	643.
UP BOND	C32	643.
UP BOND	C33	643.
UP BOND	C34	643.
UP BOND	C35	643.
UP BOND	C36	643.
UP BOND	C37	604.
UP BOND	C38	604.
UP BOND	C39	604.
UP BOND	C40	604.
UP BOND	C41	604.
UP BOND	C42	604.
UP BOND	C43	604.
UP BOND	C44	604.
UP BOND	C45	604.
UP BOND	C46	604.
UP BOND	C47	604.
UP BOND	C48	604.
UP BOND	C49	411.
UP BOND	C50	411.
UP BOND	C51	411.
UP BOND	C52	411.
UP BOND	C53	411.
UP BOND	C54	411.
UP BOND	C55	411.
UP BOND	C56	411.
UP BOND	C57	411.
UP BOND	C58	411.
UP BOND	C59	411.
UP BOND	C60	411.
UP BOND	C61	201.
UP BOND	C62	201.
UP BOND	C63	201.
UP BOND	C64	201.
UP BOND	C65	201.
UP BOND	C66	201.
UP BOND	C67	201.

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UP BOND       C68        201.
UP BOND       C69        201.
UP BOND       C70        201.
UP BOND       C71        201.
UP BOND       C72        201.
UP BOND       C73       3531.
UP BOND       C74       3531.
UP BOND       C75       3531.
UP BOND       C76       3531.
UP BOND       C77       3531.
UP BOND       C78       3531.
UP BOND       C79       3531.
UP BOND       C80       3531.
UP BOND       C81       3531.
UP BOND       C82       3531.
UP BOND       C83       3531.
UP BOND       C84       3531.
UP BOND       C85        466.
UP BOND       C86        466.
UP BOND       C87        466.
UP BOND       C88        466.
UP BOND       C89        466.
UP BOND       C90        466.
UP BOND       C91        466.
UP BOND       C92        466.
UP BOND       C93        466.
UP BOND       C94        466.
UP BOND       C95        466.
UP BOND       C96        466.
UP BOND       C97        847.
UP BOND       C98        847.
UP BOND       C99        847.
UP BOND       C100       847.
UP BOND       C101       847.
UP BOND       C102       847.
UP BOND       C103       847.
UP BOND       C104       847.
UP BOND       C105       847.
UP BOND       C106       847.
UP BOND       C107       847.
UP BOND       C108       847.
ENDATA
/*
//
```

C. COMPUTER DATA FOR FROZEN GOODS MODEL

```
//RAY JOB (IE239,7R),'RAYDROGAN',MSGLEVEL=1,NOTIFY=IE239RD
/*JOBPARM TIME=19,LINES=10K
/*ROUTE  PRINT RMT9
//* THIS IS MPSX3:  CONTINUOUS FROZEN MODEL
// EXEC MPSX
//MPSCOMP.SYSIN DD *
          PROGRAM
          INITIALZ
          TITLE('A.U.FOOD SERVICES')
          MOVE(XDATA,'DATA1')
          MOVE(XPBNAME,'BEST BUY')
          MOVE(XRHS,'LBS')
          MOVE(XOBJ,'OBJFUN')
          CONVERT('SUMMARY')
          SETUP('MIN')
          BCDOUT
          PICTURE
          TRANCOL
          OPTIMIZE
          SOLUTION
          EXIT
          PEND
//MPSEXEC.SYSIN DD *
NAME          DATA1
ROWS
 N  OBJFUN
 L  R12
 L  R13
 L  R14
 L  R15
 L  R16
 L  R17
 L  R18
 L  R19
 L  R20
 L  R21
 L  R22
 L  R23
 E  R24
 E  R25
 E  R26
 E  R27
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E R28
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 E  R130
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 E  R142
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 E  R145
 E  R146
 E  R147
 E  R148
 E  R149
 E  R150
 E  R151
 E  R152
 E  R153
 E  R154
 E  R155
COLUMNS
    C1        OBJFUN       0.559
    C1        R12          0.02538    R24        1.
    C2        OBJFUN       0.499
    C2        R13          0.02538    R25        1.
    C3        OBJFUN       0.490
    C3        R14          0.02538    R26        1.
    C4        OBJFUN       0.572
    C4        R15          0.02538    R27        1.
    C5        OBJFUN       0.450
    C5        R16          0.02538    R28        1.
    C6        OBJFUN       0.486
    C6        R17          0.02538    R29        1.
    C7        OBJFUN       0.539
    C7        R18          0.02538    R30        1.
    C8        OBJFUN       0.556
    C8        R19          0.02538    R31        1.
    C9        OBJFUN       0.588
    C9        R20          0.02538    R32        1.
    C10       OBJFUN       0.567
    C10       R21          0.02538    R33        1.
    C11       OBJFUN       0.658
    C11       R22          0.02538    R34        1.
    C12       OBJFUN       0.520
    C12       R23          0.02538    R35        1.
    C13       OBJFUN       0.082
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C13	R12	0.03013	R36	1.
C14	OBJFUN	0.087		
C14	R13	0.03013	R37	1.
C15	OBJFUN	0.066		
C15	R14	0.03013	R38	1.
C16	OBJFUN	0.068		
C16	R15	0.03013	R39	1.
C17	OBJFUN	0.071		
C17	R16	0.03013	R40	1.
C18	OBJFUN	0.069		
C18	R17	0.03013	R41	1.
C19	OBJFUN	0.075		
C19	R18	0.03013	R42	1.
C20	OBJFUN	0.091		
C20	R19	0.03013	R43	1.
C21	OBJFUN	0.087		
C21	R20	0.03013	R44	1.
C22	OBJFUN	0.072		
C22	R21	0.03013	R45	1.
C23	OBJFUN	0.064		
C23	R22	0.03013	R46	1.
C24	OBJFUN	0.073		
C24	R23	0.03013	R47	1.
C25	OBJFUN	0.256		
C25	R12	0.03629	R48	1.
C26	OBJFUN	0.235		
C26	R13	0.03629	R49	1.
C27	OBJFUN	0.321		
C27	R14	0.03629	R50	1.
C28	OBJFUN	0.194		
C28	R15	0.03629	R51	1.
C29	OBJFUN	0.148		
C29	R16	0.03629	R52	1.
C30	OBJFUN	0.155		
C30	R17	0.03629	R53	1.
C31	OBJFUN	0.160		
C31	R18	0.03629	R54	1.
C32	OBJFUN	0.177		
C32	R19	0.03629	R55	1.
C33	OBJFUN	0.174		
C33	R20	0.03629	R56	1.
C34	OBJFUN	0.222		
C34	R21	0.03629	R57	1.
C35	OBJFUN	0.214		
C35	R22	0.03629	R58	1.
C36	OBJFUN	0.224		
C36	R23	0.03629	R59	1.
C37	OBJFUN	0.105		
C37	R12	0.03013	R60	1.
C38	OBJFUN	0.114		
C38	R13	0.03013	R61	1.
C39	OBJFUN	0.101		

C39	R14	0.03013	R62	1.
C40	OBJFUN	0.099		
C40	R15	0.03013	R63	1.
C41	OBJFUN	0.093		
C41	R16	0.03013	R64	1.
C42	OBJFUN	0.095		
C42	R17	0.03013	R65	1.
C43	OBJFUN	0.105		
C43	R18	0.03013	R66	1.
C44	OBJFUN	0.140		
C44	R19	0.03013	R67	1.
C45	OBJFUN	0.130		
C45	R20	0.03013	R68	1.
C46	OBJFUN	0.118		
C46	R21	0.03013	R69	1.
C47	OBJFUN	0.100		
C47	R22	0.03013	R70	1.
C48	OBJFUN	0.094		
C48	R23	0.03013	R71	1.
C49	OBJFUN	0.408		
C49	R12	0.01790	R72	1.
C50	OBJFUN	0.421		
C50	R13	0.01790	R73	1.
C51	OBJFUN	0.415		
C51	R14	0.01790	R74	1.
C52	OBJFUN	0.408		
C52	R15	0.01790	R75	1.
C53	OBJFUN	0.424		
C53	R16	0.01790	R76	1.
C54	OBJFUN	0.445		
C54	R17	0.01790	R77	1.
C55	OBJFUN	0.462		
C55	R18	0.01790	R78	1.
C56	OBJFUN	0.445		
C56	R19	0.01790	R79	1.
C57	OBJFUN	0.434		
C57	R20	0.01790	R80	1.
C58	OBJFUN	0.411		
C58	R21	0.01790	R81	1.
C59	OBJFUN	0.393		
C59	R22	0.01790	R82	1.
C60	OBJFUN	0.377		
C60	R23	0.01790	R83	1.
C61	OBJFUN	0.535		
C61	R12	.02976	R84	1.0
C62	OBJFUN	0.509		
C62	R13	0.02976	R85	1.0
C63	OBJFUN	0.526		
C63	R14	0.02976	R86	1.0
C64	OBJFUN	0.523		
C64	R15	0.02976	R87	1.0
C65	OBJFUN	0.525		

C65	R16	0.02976	R88	1.0
C66	OBJFUN	0.523		
C66	R17	0.02976	R89	1.0
C67	OBJFUN	0.535		
C67	R18	0.02976	R90	1.0
C68	OBJFUN	0.548		
C68	R19	0.02976	R91	1.0
C69	OBJFUN	0.550		
C69	R20	0.02976	R92	1.0
C70	OBJFUN	0.560		
C70	R21	0.02976	R93	1.0
C71	OBJFUN	0.583		
C71	R22	0.02976	R94	1.0
C72	OBJFUN	0.594		
C72	R23	0.02976	R95	1.0
C73	OBJFUN	0.867		
C73	R12	0.02110	R96	1.0
C74	OBJFUN	0.853		
C74	R13	0.02110	R97	1.0
C75	OBJFUN	0.839		
C75	R14	0.02110	R98	1.0
C76	OBJFUN	0.837		
C76	R15	0.02110	R99	1.0
C77	OBJFUN	0.879		
C77	R16	0.02110	R100	1.0
C78	OBJFUN	0.888		
C78	R17	0.02110	R101	1.0
C79	OBJFUN	0.894		
C79	R18	0.02110	R102	1.0
C80	OBJFUN	0.889		
C80	R19	0.02110	R103	1.0
C81	OBJFUN	0.871		
C81	R20	0.02110	R104	1.0
C82	OBJFUN	0.872		
C82	R21	0.02110	R105	1.0
C83	OBJFUN	0.873		
C83	R22	0.02110	R106	1.0
C84	OBJFUN	0.869		
C84	R23	0.02110	R107	1.0
C85	OBJFUN	1.340		
C85	R12	0.01932	R108	1.0
C86	OBJFUN	1.272		
C86	R13	0.01932	R109	1.0
C87	OBJFUN	1.267		
C87	R14	0.01932	R110	1.0
C88	OBJFUN	1.241		
C88	R15	0.01932	R111	1.0
C89	OBJFUN	1.239		
C89	R16	0.01932	R112	1.0
C90	OBJFUN	1.257		
C90	R17	0.01932	R113	1.0
C91	OBJFUN	1.287		

C91	R18	0.01932	R114	1.0
C92	OBJFUN	1.299		
C92	R19	0.01932	R115	1.0
C93	OBJFUN	1.307		
C93	R20	0.01932	R116	1.0
C94	OBJFUN	1.351		
C94	R21	0.01932	R117	1.0
C95	OBJFUN	1.358		
C95	R22	0.01932	R118	1.0
C96	OBJFUN	1.406		
C96	R23	0.01932	R119	1.0
C97	OBJFUN	0.734		
C97	R12	0.02109	R120	1.0
C98	OBJFUN	0.756		
C98	R13	0.02109	R121	1.0
C99	OBJFUN	0.745		
C99	R14	0.02109	R122	1.0
C100	OBJFUN	0.744		
C100	R15	0.02109	R123	1.0
C101	OBJFUN	0.754		
C101	R16	0.02109	R124	1.0
C102	OBJFUN	0.742		
C102	R17	0.02109	R125	1.0
C103	OBJFUN	0.737		
C103	R18	0.02109	R126	1.0
C104	OBJFUN	0.738		
C104	R19	0.02109	R127	1.0
C105	OBJFUN	0.737		
C105	R20	0.02109	R128	1.0
C106	OBJFUN	0.748		
C106	R21	0.02109	R129	1.0
C107	OBJFUN	0.773		
C107	R22	0.02109	R130	1.0
C108	OBJFUN	0.804		
C108	R23	0.02109	R131	1.0
C109	OBJFUN	0.712		
C109	R12	0.01953	R132	1.0
C110	OBJFUN	0.716		
C110	R13	0.01953	R133	1.0
C111	OBJFUN	0.735		
C111	R14	0.01953	R134	1.0
C112	OBJFUN	0.751		
C112	R15	0.01953	R135	1.0
C113	OBJFUN	0.775		
C113	R16	0.01953	R136	1.0
C114	OBJFUN	0.804		
C114	R17	0.01953	R137	1.0
C115	OBJFUN	0.829		
C115	R18	0.01953	R138	1.0
C116	OBJFUN	0.833		
C116	R19	0.01953	R139	1.0
C117	OBJFUN	0.829		

C117	R20	0.01953	R140	1.0
C118	OBJFUN	0.841		
C118	R21	0.01953	R141	1.0
C119	OBJFUN	0.851		
C119	R22	0.01953	R142	1.0
C120	OBJFUN	0.857		
C120	R23	0.01953	R143	1.0
C121	OBJFUN	0.385		
C121	R12	0.08051	R144	1.0
C122	OBJFUN	0.388		
C122	R13	0.08051	R145	1.0
C123	OBJFUN	0.405		
C123	R14	0.08051	R146	1.0
C124	OBJFUN	0.421		
C124	R15	0.08051	R147	1.0
C125	OBJFUN	0.441		
C125	R16	0.08051	R148	1.0
C126	OBJFUN	0.450		
C126	R17	0.08051	R149	1.0
C127	OBJFUN	0.471		
C127	R18	0.08051	R150	1.0
C128	OBJFUN	0.492		
C128	R19	0.08051	R151	1.0
C129	OBJFUN	0.505		
C129	R20	0.08051	R152	1.0
C130	OBJFUN	0.505		
C130	R21	0.08051	R153	1.0
C131	OBJFUN	0.506		
C131	R22	0.08051	R154	1.0
C132	OBJFUN	0.507		
C132	R23	0.08051	R155	1.0
C133	R13	0.02538	R24	-1.0
C133	R25	1.0		
C134	R14	0.02058	R25	-1.0
C134	R26	1.0		
C135	R15	0.02058	R26	-1.0
C135	R27	1.0		
C136	R16	0.02058	R27	-1.0
C136	R28	1.0		
C137	R17	0.02058	R28	-1.0
C137	R29	1.0		
C138	R18	0.02058	R29	-1.0
C138	R30	1.0		
C139	R19	0.02058	R30	-1.0
C139	R31	1.0		
C140	R20	0.02058	R31	-1.0
C140	R32	1.0		
C141	R21	0.02058	R32	-1.0
C141	R33	1.0		
C142	R22	0.02058	R33	-1.0
C142	R34	1.0		
C143	R23	0.02058	R34	-1.0

C143	R35	1.0		
C144	R12	0.02058	R24	1.0
C144	R35	-1.0		
C145	R13	0.03013	R36	-1.
C145	R37	1.0		
C146	R14	0.03013	R37	-1.
C146	R38	1.0		
C147	R15	0.03013	R38	-1.
C147	R39	1.0		
C148	R16	0.03013	R39	-1.
C148	R40	1.0		
C149	R17	0.03013	R40	-1.
C149	R41	1.0		
C150	R18	0.03013	R41	-1.
C150	R42	1.0		
C151	R19	0.03013	R42	-1.
C151	R43	1.0		
C152	R20	0.03013	R43	-1.
C152	R44	1.0		
C153	R21	0.03013	R44	-1.
C153	R45	1.0		
C154	R22	0.03013	R45	-1.
C154	R46	1.0		
C155	R23	0.03013	R46	-1.
C155	R47	1.0		
C156	R12	0.03013	R36	1.
C156	R47	-1.0		
C157	R13	0.03629	R48	-1.0
C157	R49	1.0		
C158	R14	0.03629	R49	-1.0
C158	R50	1.0		
C159	R15	0.03629	R50	-1.0
C159	R51	1.0		
C160	R16	0.03629	R51	-1.0
C160	R52	1.0		
C161	R17	0.03629	R52	-1.0
C161	R53	1.0		
C162	R18	0.03629	R53	-1.0
C162	R54	1.0		
C163	R19	0.03629	R54	-1.0
C163	R55	1.0		
C164	R20	0.03629	R55	-1.0
C164	R56	1.0		
C165	R21	0.03629	R56	-1.0
C165	R57	1.0		
C166	R22	0.03629	R57	-1.0
C166	R58	1.0		
C167	R23	0.03629	R58	-1.0
C157	R59	1.0		
C168	R12	0.03629	R48	1.0
C168	R59	-1.0		
C169	R13	0.03013	R60	-1.

C169	R61	1.0		
C170	R14	0.03013	R61	-1.
C170	R62	1.0		
C171	R15	0.03013	R62	-1.
C171	R63	1.0		
C172	R16	0.03013	R63	-1.
C172	R64	1.0		
C173	R17	0.03013	R64	-1.
C173	R65	1.0		
C174	R18	0.03013	R65	-1.
C174	R66	1.0		
C175	R19	0.03013	R66	-1.
C175	R67	1.0		
C176	R20	0.03013	R67	-1.
C176	R68	1.0		
C177	R21	0.03013	R68	-1.
C177	R69	1.0		
C178	R22	0.03013	R69	-1.
C178	R70	1.0		
C179	R23	0.03013	R70	-1.
C179	R71	1.0		
C180	R12	0.03013	R60	1.
C180	R71	-1.0		
C181	R13	0.01790	R72	-1.0
C181	R73	1.0		
C182	R14	0.01790	R73	-1.0
C182	R74	1.0		
C183	R15	0.01790	R74	-1.0
C183	R75	1.0		
C184	R16	0.01790	R75	-1.0
C184	R76	1.0		
C185	R17	0.01790	R76	-1.0
C185	R77	1.0		
C186	R18	0.01790	R77	-1.0
C186	R78	1.0		
C187	R19	0.01790	R78	-1.0
C187	R79	1.0		
C188	R20	0.01790	R79	-1.0
C188	R80	1.0		
C189	R21	0.01790	R80	-1.0
C189	R81	1.0		
C190	R22	0.01790	R81	-1.0
C190	R82	1.0		
C191	R23	0.01790	R82	-1.0
C191	R83	1.0		
C192	R12	0.01790	R72	1.0
C192	R83	-1.0		
C193	R13	0.02976	R84	-1.
C193	R85	1.0		
C194	R14	0.02976	R85	-1.
C194	R86	1.0		
C195	R15	0.02976	R86	-1.

C195	R87	1.0		
C196	R16	0.02976	R87	-1.
C196	R88	1.0		
C197	R17	0.02976	R88	-1.
C197	R89	1.0		
C198	R18	0.02976	R89	-1.
C198	R90	1.0		
C199	R19	0.02976	R90	-1.
C199	R91	1.0		
C200	R20	0.02976	R91	-1.
C200	R92	1.0		
C201	R21	0.02976	R92	-1.
C201	R93	1.0		
C202	R22	0.02976	R93	-1.
C202	R94	1.0		
C203	R23	0.02976	R94	-1.
C203	R95	1.0		
C204	R12	0.02976	R84	1.
C204	R95	-1.0		
C205	R13	0.02110	R96	-1.0
C205	R97	1.0		
C206	R14	0.02110	R97	-1.0
C206	R98	1.0		
C207	R15	0.02110	R98	-1.0
C207	R99	1.0		
C208	R16	0.02110	R99	-1.0
C208	R100	1.0		
C209	R17	0.02110	R100	-1.0
C209	R101	1.0		
C210	R18	0.02110	R101	-1.0
C210	R102	1.0		
C211	R19	0.02110	R102	-1.0
C211	R103	1.0		
C212	R20	0.02110	R103	-1.0
C212	R104	1.0		
C213	R21	0.02110	R104	-1.0
C213	R105	1.0		
C214	R22	0.02110	R105	-1.0
C214	R106	1.0		
C215	R23	0.02110	R106	-1.0
C215	R107	1.0		
C216	R12	0.02110	R96	1.0
C216	R107	-1.0		
C217	R13	0.01932	R108	-1.
C217	R109	1.0		
C218	R14	0.01932	R109	-1.
C218	R110	1.0		
C219	R15	0.01932	R110	-1.
C219	R111	1.0		
C220	R16	0.01932	R111	-1.
C220	R112	1.0		
C221	R17	0.01932	R112	-1.

C221	R113	1.0		
C222	R18	0.01932	R113	-1.
C222	R114	1.0		
C223	R19	0.01932	R114	-1.
C223	R115	1.0		
C224	R20	0.01932	R115	-1.
C224	R116	1.0		
C225	R21	0.01932	R116	-1.
C225	R117	1.0		
C226	R22	0.01932	R117	-1.
C226	R118	1.0		
C227	R23	0.01932	R118	-1.
C227	R119	1.0		
C228	R12	0.01932	R108	1.
C228	R119	-1.0		
C229	R13	0.02109	R120	-1.0
C229	R121	1.0		
C230	R14	0.02109	R121	-1.0
C230	R122	1.0		
C231	R15	0.02109	R122	-1.0
C231	R123	1.0		
C232	R16	0.02109	R123	-1.0
C232	R124	1.0		
C233	R17	0.02109	R124	-1.0
C233	R125	1.0		
C234	R18	0.02109	R125	-1.0
C234	R126	1.0		
C235	R19	0.02109	R126	-1.0
C235	R127	1.0		
C236	R20	0.02109	R127	-1.0
C236	R128	1.0		
C237	R21	0.02109	R128	-1.0
C237	R129	1.0		
C238	R22	0.02109	R129	-1.0
C238	R130	1.0		
C239	R23	0.02109	R130	-1.0
C239	R131	1.0		
C240	R12	0.02109	R120	1.0
C240	R131	-1.0		
C241	R13	0.01953	R132	-1.
C241	R133	1.0		
C242	R14	0.01953	R133	-1.
C242	R134	1.0		
C243	R15	0.01953	R134	-1.
C243	R135	1.0		
C244	R16	0.01953	R135	-1.
C244	R136	1.0		
C245	R17	0.01953	R136	-1.
C245	R137	1.0		
C246	R18	0.01953	R137	-1.
C246	R138	1.0		
C247	R19	0.01953	R138	-1.

C247	R139	1.0		
C248	R20	0.01953	R139	-1.
C248	R140	1.0		
C249	R21	0.01953	R140	-1.
C249	R141	1.0		
C250	R22	0.01953	R141	-1.
C250	R142	1.0		
C251	R23	0.01953	R142	-1.
C251	R143	1.0		
C252	R12	0.01953	R132	1.
C252	R143	-1.0		
C253	R13	0.08051	R144	-1.0
C253	R145	1.0		
C254	R14	0.08051	R145	-1.0
C254	R146	1.0		
C255	R15	0.08051	R146	-1.0
C255	R147	1.0		
C256	R16	0.08051	R147	-1.0
C256	R148	1.0		
C257	R17	0.08051	R148	-1.0
C257	R149	1.0		
C258	R18	0.08051	R149	-1.0
C258	R150	1.0		
C259	R19	0.08051	R150	-1.0
C259	R151	1.0		
C260	R20	0.08051	R151	-1.0
C260	R152	1.0		
C261	R21	0.08051	R152	-1.0
C261	R153	1.0		
C262	R22	0.08051	R153	-1.0
C262	R154	1.0		
C263	R23	0.08051	R154	-1.0
C263	R155	1.0		
C264	R12	0.08051	R144	1.0
C264	R155	-1.0		

RHS

LBS	R12	1242.0246		
LBS	R13	1242.0246	R14	1242.0246
LBS	R15	1242.0246	R16	1242.0246
LBS	R17	1242.0246	R18	1242.0246
LBS	R19	1242.0246	R20	1242.0246
LBS	R21	1242.0246	R22	1242.0246
LBS	R23	1242.0246	R24	884.
LBS	R25	994.	R26	634.
LBS	R27	966.	R28	998.
LBS	R29	618.	R30	761.
LBS	R31	662.5	R32	336.
LBS	R33	1041.5	R34	1008.
LBS	R35	268.5	R36	374.
LBS	R37	373.	R38	267.
LBS	R39	400.	R40	414.
LBS	R41	307.	R42	414.

LBS	R43	360.	R44	133.
LBS	R45	414.	R46	400.
LBS	R47	107.	R48	1739.
LBS	R49	1739.	R50	1274.
LBS	R51	2105.	R52	2175.
LBS	R53	1250.	R54	1469.
LBS	R55	1280.	R56	881.
LBS	R57	2730.	R58	2642.
LBS	R59	705.	R60	1513.
LBS	R61	1513.	R62	1051.
LBS	R63	1396.	R64	1443.
LBS	R65	904.	R66	1120.
LBS	R67	976.	R68	641.
LBS	R69	1987.	R70	1923.
LBS	R71	513.	R72	255.
LBS	R73	255.	R74	190.
LBS	R75	333.	R76	344.
LBS	R77	168.	R78	174.
LBS	R79	152.	R80	223.
LBS	R81	692.	R82	670.
LBS	R83	179.	R84	5779.
LBS	R85	5779.	R86	4129.5
LBS	R87	6198.	R88	6404.
LBS	R89	2808.	R90	2639.
LBS	R91	2298.5	R92	2649.
LBS	R93	8211.	R94	7946.5
LBS	R95	2119.	R96	7739.
LBS	R97	7739.	R98	5334.
LBS	R99	6843.	R100	7071.
LBS	R101	4014.	R102	4684.
LBS	R103	4080.	R104	2841.
LBS	R105	8808.	R106	8524.
LBS	R107	2273.	R108	3879.5
LBS	R109	3879.5	R110	2712.
LBS	R111	3716.	R112	3839.
LBS	R113	2239.5	R114	2659.
LBS	R115	2316.	R116	1602.
LBS	R117	4967.	R118	4807.
LBS	R119	1282.	R120	990.
LBS	R121	990.	R122	703.
LBS	R123	1028.	R124	1062.
LBS	R125	735.	R126	959.
LBS	R127	935.	R128	272.
LBS	R129	843.	R130	816.
LBS	R131	217.	R132	1525.
LBS	R133	1525.	R134	1056.
LBS	R135	1384.	R136	1430.
LBS	R137	897.	R138	1113.
LBS	R139	970.	R140	468.
LBS	R141	1452.	R142	1405.
LBS	R143	375.	R144	68.
LBS	R145	68.	R146	48.

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         LBS       R147       73.        R148       75.
         LBS       R149       69.        R150      100.
         LBS       R151       87.        R152       62.
         LBS       R153      193.        R154      187.
         LBS       R155       50.
ENDATA
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MED